EFFECTS OF FIRE
ON
FORESTS
A BIBLIOGRAPHY

COMPILED AND ANNOTATED

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FOREWORD

Forest fires have been the subject of such a large body of literature that no attempt to assemble it in one comprehensive bibliography has been made at this time. It is planned that this bibliography, "Effects of Fire on Forests," will be followed by others, each embracing one phase of the forest fire problem, eventually to be collated and issued as such a comprehensive bibliography.

The many factors involved in the direct and indirect effects of fire are in most cases so complex and closely related that to separate them into hard and fast categories is difficult. In order to facilitate the use of this bibliography by research workers in various fields, "See also" entries and an author index have been added as aids to users who know that certain men have contributed to the literature but who are not sure where to locate their writings in the classified list.

Except for the section "Historical," which includes references from the early 1800's, the period covered in this bibliography is from about 1912 to September 1938. Textbooks on general forestry and forest protection have as a rule been omitted, although they contain basic material on effects of fire, because the users of a specialized bibliography are presumably already familiar with them.

Emphasis has been placed upon North American forestry literature and the greater number of references cited are in English. Through use of the Bibliographia Universalis Silviculturae from foreign libraries affiliated with the International Union of Forest Research Organizations, outstanding foreign references have been included. The bibliography is selective except in the section "Light or Controlled Burning: Fire Protection," where, for their historical interest, all articles which have come to the compiler's attention have been included.

When available, abstracts from Biological Abstracts and Experiment Station Record have been used in lieu of annotations. All other abstracts and annotations, when not acknowledged, have been prepared in the Forest Service Library. No attempt has been made to compare, analyze or evaluate the references included.

Washington, D. C.
September 15, 1938.

Mildred B. Williams, Librarian.
U. S. Forest Service Library.

SOURCES CONSULTED

Card catalogs of the following libraries:
U. S. Department of Agriculture.
U. S. Forest Service.
U. S. Library of Congress.

Agricultural Index, 1916 - September 1938. Published by the H. W. Wilson Company, New York, N. Y.

Bibliographia Universalis Silviculturae. Published under the auspices of the International Union of Forest Research Organizations (various countries and dates).

Botanical Abstracts, v. 1-15, 1918-1926. Published under the direction of the Board of Control of Botanical Abstracts, Inc., by Williams and Wilkins, Baltimore, Md.

Biological Abstracts, v. 1, 1926 - v. 12, no. 3, July 1938. Published under the auspices of the Union of American Biological Societies. University of Pennsylvania, Philadelphia, Pa.

Experiment Station Record, 1889 - April 1938. Published by the Office of Experiment Stations, U. S. Department of Agriculture.

Forestry Current Literature, 1904 - July/August 1938. Published by the Forest Service, U. S. Department of Agriculture.

U. S. Forest Service. Complete List of Forest Service Publications. Rev. Feb. 16, 1936. Washington, D. C. 122p. mimeo.

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HISTORICAL

1. BARTRAM, William. The travels of William Bartram. [New York] Macy-Masius, 1928. 414p. (An American bookshelf series, edited by Mark van Doren.)
   Book was first published in Philadelphia in 1791. Excerpt from p. 149 (in Florida): "The trees and shrubs which cover these extensive wilds are about five or six feet high, and seem to be kept down by annual firing of the deserts, rather than the barrenness of the soil, as I saw a few large live oaks, mulberry trees, and hiccories, which evidently have withstood the devouring flames."

2. BURCKHARDT, J. L. Travels in Syria and the Holy Land. London, John Murray, 1822. 668p.
   From p. 331: "In returning from the Kalaat Hamam I was several times reprimanded by my guide, for not taking proper care of the lighted tobacco that fell from my pipe... The Arabs who inhabit the valley of the Jordan invariably put to death any person who is known to have been even the innocent cause of firing the grass..." A further quotation from Burckhardt on fire in the valley of the Jordan appears in Indian Forester 22(4): 144-145. Apr. 1896.

3. BYRD, William. History of the dividing line, and other tracts. From the papers of William Byrd of Westover, Va. Richmond, Va., 1866. 2 vol. Half-title: Historical documents from the Old Dominion, no. 2-3, edited by T. H. Wynne.
   Vol. 1, p. 120, 129 and 170 describe the methods used by the Indians in burning grassland and forests for hunting. These quotations, and notes by E. N. Munns appear in Serv. Bul. (U. S. Forest Serv.) 16(6): 1-2. Feb. 8, 1932.

4. C., A. Fire protection in fields and forests. Indian Forester 22(4): 144-145. Apr. 1896.
Includes a quotation from Virgil on burning of land, which he considered beneficial. Also quotation from Burckhardt, in his travels in Palestine, about Arabs and their laws regarding fire. (See entry no. 2.)

5. [CAMBY, Jacques.] Notice sur l'agriculture des Celtes, et des Gaulois. Paris, [Imprimerie de Crapelet], 1806. 42p.
Includes notes on the use of different kinds of ashes as fertilizers by the Bretons in early times, and from this practice, we assume, grew the custom of firing the land to improve poor soils.

6. CARRIER, Lyman. The beginnings of agriculture in America. New York, McGraw-Hill book co., 1923. 323p. illus.
From p. 38: "The Indians were able to clear land overgrown with trees without saws, axes or other tools of Metal. Capt. John Smith states that they accomplished this by first bruising the bark near the roots and then scorching them with fire.. By this method, they had made many extensive clearings in the eastern part of the continent. The Indians usually picked the most fruitful soil in their locality for their farming and we find them generally situated on river bottoms or near other bodies of water." From p. 26: "As the forest became older and older the weaker specimens among the trees became overshadowed and finally succumbed while the conditions became less and less favorable for seedling trees and shrubs to grow. Annual fires also contributed towards keeping down the undergrowth. The Indian practice of burning areas to attract deer, elk and buffalo with the succulent growth of grass which sprang up after the fire had passed might be cited as a step towards pasture management." From p. 197: "Brickell who was a practising physician in North Carolina about 1731 notes: 'As for Hay, I never observed any made in the Country, tho' they have such plenty of Grass, that they are obliged to burn it off the Ground every 10th of March, by virtue of a Law made in the Country for that purpose.' The purpose of this law was to burn old unpalatable growth and renew the pastures with tender succulent grass rather than to get rid of an over supply of forage, as stated by Brickell."

7. DAUBENY, Charles. Lectures on Roman husbandry... Oxford, Ptd. by James Wright, 1857. 328p.
p. 91: "Columella and the other prose authors on husbandry scarcely allude to the practice of improving the soil by burning, which Virgil has so graphically described, pointing out in his subsequent lines the three principal causes, upon which the advantage of burning is supposed by modern farmers to depend.... Whether, that is, it communicates rich juices to the land, or corrects bad ones; opens the pores of the soil

to allow the nutritious juices access to the young plants, or renders it more compact; so as to prevent its being injured, either by the showers, excessive heat of summer, or the severe cold of winter. Now the advantages recognized at the present day as arising from the practice of burning the soil, and the plants which cover its surface, are very much of the description which Virgil has stated. ... This is the source of the fertility imparted to the soil in America by the combustion of the timber in its extensive forests; the fire unlocking, as it were, those accumulations of potash, phosphate of lime, and other valuable matters, which the trees in their growth had gradually drawn from the soil, and restoring them at once in a condition in which they can minister to the wants of the forthcoming crops." This book refers to Palladius as writing on the subject, and quotes from Virgil's Georgics.

8. DWIGHT, Timothy. Travels in New England and New York. New Haven, T. Dwight, 1821-22. 4 vol.

Vols. 1, 2 and 4 contain information concerning firing of land by Indians, which the author thinks has been done in New England for more than 1000 years, and foolishly continued by the English settlers. Oak and yellow pine forests were annually burned because they were dry enough to burn on the uplands; beech and maple grounds were too wet to burn. The result was that the vegetable mold on these latter grounds was from 6 inches to 1 foot deep, while on the former, the litter was not an inch deep, which the author attributes entirely to the annual burning. In vol. 4, p. 60-64 the advantages and disadvantages of burning pastures and agricultural land are discussed in some detail, with emphasis on litter and humus.

9. FAUX, W. Memorable days in America. London, W. Simpkin and R. Marshall, 1823. 488p.

How fire was used in the early days in slaughtering passenger pigeons. An excerpt from this book, contributed by E. N. Munns, appears in Service Bul. (U. S. Forest Serv.) 16(16): 5-6. Apr. 18, 1932.

10. FERRIS, Benjamin. A history of the original settlements on the Delaware under William Penn. Wilmington, Wilson and Heald, 1846. 312p. illus.

Includes some information on light burning by the Indians, which the first settlers noted.

11. HENNEPIN, Louis. A new discovery of a vast country in America. London, Printed for M. Bentley, J. Tonson, H. Benwick, T. Goodwin, and S. Manship, 1698. [355]p.

Father Hennepin in his writings commented on the plains of Illinois and attributed their origin to the annual firing of the land by the Miami Indians. Excerpt, contributed by E. N. Munns, appears in Service Bul. (U. S. Forest Serv.) 13(46): 8. Nov. 18, 1929.

12. JONES, Hugh. The present state of Virginia. London, Printed for J. Clarke, 1724. 151p.

In describing the early forests of the Atlantic Coast Plain, the author notes that there were few openings except where the Indians, and later the pioneers, had burned. Excerpt, contributed by E. N. Munns, appears in Service Bul. (U. S. Forest Serv.) 17(22): 5. Oct. 23, 1933.

13. LA ROCHEFOUCAULD LIANCOURT. Travels through the United States of North America... in the years 1795, 1796, and 1797. 2d. ed. London, Ptd. by T. Gillet, 1800. 4 vol.

Quotations from vol. 3 of this set on use of fire for clearing land and hunting along the Hudson appear in Service Bul. (U. S. Forest Serv.) 19(10): 8. May 13, 1935.

14. LAMBERT, John. Travels through Canada and the United States of North America, in the years of 1806, 1807, and 1808. 2d. ed., cor. and improved. London, Printed for C. Cradock and W. Joy ...1814. 2 vol.

In vol. 2 the author notes that the pine barrens have little underwood, the ground being covered with coarse grass caused by the custom of burning in the spring, to hasten pasturage. Traveling in stormy weather was made hazardous by the falling of half-burnt and scorched trees. Excerpts from this book on light burning to clear ground of long grass and brushwood, and its spreading, contributed by E. N. Munns, appears in Service Bul. (U. S. Forest Serv.) 18(14): 5. July 2, 1934.

15. LYELL, [Sir] Charles. Travels in North America. New York, Wiley and Putnam, 1845. 2 vol. in one.

Vol. 2, p. 62-63 says: "When more than half way across the State [Ohio] and after leaving Mount Vernon, we saw continually new clearings, where the felling, girdling, and burning of trees was going on, and where oats were growing amidst the blackened stumps on land which had never been ploughed, but only broken up with the harrow. The carriage was then jolted for a short space over a corduroy road, constructed of trunks of trees laid side by side, while the hot air of burning timber made us impatient of the slow pace of our carriage." Vol. 2, p. 191 (in Nova Scotia): "The road was cut through an endless forest of fir-wood, parts of which had lately suffered much by conflagrations. These

fires often spread for leagues in the summer season, and cause great devastation. The more resinous species of fir, when they have been heated by the burning of the surrounding timber, blaze up suddenly when the fire at last reaches them, and are enveloped from top to bottom in brilliant flames, presenting in the night a most splendid spectacle."

16. LYELL, [Sir] Charles. A second visit to the United States of North America. London, J. Murray, 1849. 2 vol.
This contains nothing on the practice of burning of land, or of forest fires directly, but contains a section on floods caused by denuding of the forest.

17. McBRYDE, J. M. Ancient husbandry - Rome and her provinces. Jour. Amer. Agr. Assoc. 1(3/4): 37-50. July/Oct. 1881.
Includes a note on the ancient Roman practice of burning land to increase fertility. Gives four reasons why Virgil recommended it, with quotation from the original Georgics, i. 84.

18. MACKENZIE, Alexander. Voyages from Montreal, on the River St. Lawrence through the continent of North America, to the Frozen and Pacific oceans, in the years 1789 and 1793... London, 1801. Reviewed in Edinburgh Review 1: 141-158. 1802-1803. (1803)
This explorer mentions "A very curious and extraordinary circumstance" of the spruce, pine and white birch forests, when destroyed by fire, produced nothing but poplars where none of that species were previously found in the region.

19. MICHAUX, André. Histoire des chênes de l'Amerique. Paris, De l'impr. de Crapelet, 1801. [37] p. illus.
Paragraphs from a famous French botanist on the effect of brush fires set by the early settlers, translated by E. N. Munns, appear in Service Bul. (U. S. Forest Serv.) 16(35): 6. Oct. 10, 1932.

20. MICHAUX, F. A. Travels to the west of the Alleghany mountains... in the year 1802. 2d ed. London, Ptd. for D. N. Shury, for B. Crosby and co., 1805. 294p.
Quotation from the travels of Michaux (the younger) on the practice of light burning for pasturage in Kentucky, contributed by E. N. Munns, appears in Service Bul. (U. S. Forest Serv.) 12(50): 7. Dec. 10, 1928.

21. MUIR, John. Steep trails, edited by Frederic Badé. Boston, Houghton Mifflin co., 1918. 390p.
p. 238-239 describes signs of fires of several centuries, due to drought, and the author mentions fire as a governing agent in the distribution and growth of forests.

22. MUIR, John. The writings of John Muir. Manuscript edition. Boston and New York, Houghton-Mifflin co., 1916-1924. 10 vol.

Vol. 9 and 10 of this set are vol. 1 and 2, respectively, of "The life and letters of John Muir", edited by William Frederic. Badé, published in 1923-1924. Contains descriptions of fires and their effects upon forests and ranges. Vol. 1, p. 183 describes the annual burning of sprouting oak and hickory trees. Extract from vol. 1, p. 183: "The uniformly rich soil of Illinois and Wisconsin prairies produced so close and tall a growth of grasses for fires that no trees could live on it. Had there been no fires, these prairies would have been covered by the heaviest forest. As soon as the oak openings were settled and the farmers had prevented running-fires, the grubs grew into trees."

23. MUNNS, E. N. More Indian and other early fire. Service Bul. (U. S. Forest Serv.) 17(22): 5. Oct. 23, 1933.

A note concerning writings of Bernard Romans (See entry 33) and Hugh Jones (See entry 12). Mentions also Governor Dobbs of North Carolina who complained (1752) of range burning. Early North Carolina law required that throughout the province the range be burnt annually. The law was later repealed.

24. MUNNS, E. N. More Indian fire. Service Bul. (U. S. Forest Serv.) 13(34): 7. Aug. 26, 1929.

Notes on Captain John Smith's letters and day books describing the method of fire-hunting by the Indians.

25. [MUNNS, E. N.] The Indians did use fire! Service Bul. (U. S. Forest Serv.) 12(43): 6-7. Oct. 22, 1928.

Excerpt from a letter written by Thomas Jefferson to John Adams, May 27, 1813, describing fire hunting, and suggesting that Indian burning was the cause of the origin and extension of the western prairies.

26. MUNNS, E. N. More early fire. Service Bul. (U. S. Forest Serv.) 16(30): 2-3. Aug. 1, 1932.

Quotation from an unnamed early traveler in America on Indian "fire hunting" methods which were adopted by the white settlers in New England.

27. MUNNS, E. N. More early fire! Service Bul. (U. S. Forest Serv.) 18(21): 5-6. Oct. 8, 1934.

Extract from a letter from an unnamed British officer, written during the Revolutionary War, from Richmond, Va., July 14, 1799, on light burning in that vicinity and the damaging effects.

28. NUÑEZ CABEZA de VACA, Alvar. The narrative of Alvar Núnez Cabeza de Vaca. Translated by Buckingham Smith. Wash., 1851. 134p.

In describing the customs of the Southwestern Indians this early Spanish traveler says, on p. 64: "We found mosquitoes of three sorts and all of them abundant in every part of the country. As a protection against them we made many many fires, encircling the people, using rotten and wet wood to produce smoke without flame. Those of the interior have a different method; as intolerable and even more so than the one I have spoken of; which is to go with the brands in their hands firing the plains and forest within their reach that the mosquitoes may fly away; and at the same time to drive out the lizards and other like things from the earth to eat. They are accustomed to kill deer also by surrounding them with fire. They take the pasturage from cattle by burning, that necessity may drive them to seek it in such places as it is wished they should go to."

29. PERCY, George. Observations gathered out of a discourse of the Plantation of the Southerne Colonie in Virginia by the English, 1606. (In Purchas, Samuel...Pilgrims...London, Ptd. by William Stansby, 1625. 4 vol.)

Vol. 4, book 9, p. 1686 says: "Wee marched some three or four miles further into the Woods, where we saw great smoakes of fire. Wee marched to those smoakes and found that the Savages had beene there burning doune the grasse, as wee thought either to make their plantation there, or else to give signs to bring their forces together, and to give us battell." Extracts from "Percy's Discourse", contributed by E. N. Munns, appear in Service Bul. (U. S. Forest Serv.) 13(28): 6. July 15, 1929.

30. REYNIER, L. De l'économie publique et rurale des Celtes. Geneve, J. J. Paschoud, 1818. 551p.

Mentions the use of fire in the agriculture of the Celts. Cites Pliny and Virgil.

31. RICHMAN, I. B. Ioway to Iowa. State historical society of Iowa, 1931. 479p.

Quotes various authors on prairie fires--causes, extent and results. Extracts from the book appear in Service Bul. (U. S. Forest Serv.) 15(33): 1-2. Aug. 17, 1931.

32. RILEY, R. M. Ancient Mayas burned their forests. illus. Amer. Forests 38(8): 442-443, 480. Aug. 1932.
A warning to modern advocates of periodic burning is given in this description of the Mayan method of clearing and burning their forest and agricultural land at regular intervals, each cycle impoverishing the land, which may account for the decadence of the high Mayan civilization, the abandonment of Mayan cities and their emigration into Yucatan.

33. ROMANS, Bernard. A concise natural history of east and west Florida. vol. 1. New York, Ptd. for the author, 1775. 342p.
Notes on fire in Florida set by travelers and the Indians.

34. TRUMBULL, Benjamin. A complete history of Connecticut... New Haven, Maltby, Goldsmith and co., 1818. 2 vol.
V. 1, p. 37: "Except in places where the timber has been destroyed, and its growth prevented by frequent fires, the groves were thick and lofty. The Indians so often burned the country, to take deer and other wild game, that in many of the plains, dry parts of it, there was but little small timber. Where lands were thus burned there grew bent grass, or as some called it thatch, two, three and four feet high, according to the strength of the land. This, with other combustible matter, which the fields and groves produced, when dry, in the spring and fall, burned with violence and killed all the small trees. The large ones escaped, and generally grew to a notable height and magnitude. In this manner the natives so thinned the groves, that they were able to plant their corn and obtain a crop." Excerpts from this history, contributed by E. N. Munns, appear in Service Bul. (U. S. Forest Serv.) 13(23): 5-6. June 10, 1929.

35. VRIES, D. P. de. Voyages from Holland to America, A. D. 1632 to 1644. (In New York historical soc. Collections. 2d. ser. vol. 3, pt. 1. New York, Appleton, 1857).
Mentions firing of the forests by Indians for hunting, and resultant growth of "sweet-smelling herbs, as sassafras."

36. ASHE, W. W. Forest fires: their destructive work, causes and prevention. Raleigh, N. C., 1895. 66p. (N. C. Geol. Surv. Bul. 7)

The changes produced in longleaf pine forests by fire--effect on seed and seedling, early and later growth and on naval stores; the effect of fire on other coniferous and hardwood trees and forest soil.

37. BAKER, H. L. Forest fires in Florida; published by Florida forestry assoc., in cooperation with the Forest service, U. S. Dept. of agriculture. [Jacksonville, Fla?] 1926. 37p. illus.

p. 3-12 covers the direct and indirect effects of fire upon young growth, merchantable timber, soil, wildlife and range.

38. BARRETT, L. A. From an old report. Service Bul. (U. S. Forest Serv.) 17(17): 2-3. Aug. 14, 1933.

An extract from a Plumas Boundary Report of 1904 on effects of fires, especially of light fires which at first sight seem to do little damage. Includes (1) damage to reproduction, (2) damage to mature trees, and resultant rot, (3) production of an open forest of low-limbed trees, (4) extension of chaparral in the forest.

39. BELL, Robert. Forest fires in northern Canada. Proc. Amer. Forestry Cong. 7: 50-55. 1888. (1889)

Includes effect of fire upon forest soils, upon Banksian pine and upon forest succession.

40. C., O. On "leaf fires." The destruction caused by "leaf" or light annual brush fires. Indian Forester 27(3): 124-125. March 1901.

Reproduction is damaged, no matter how light the fire, injury to the base of standing timber occurs, and the forest type is, in time, completely altered, this Indian forester asserts.

41. CARTER, H. Fire protection in the teak forests of Burma. Indian Forester 30(8): 363-366. Aug. 1904.

Advantages of fire protection in the teak forests of Burma are: Soil improvement, protection of seedlings, and protection of logs. The disadvantages are: Loss of germinating power of teak seed, choking of seedlings, increase of insects, unpassability of forest, estrangement of villagers because of restrictions, loss of nearly the whole working season due to fire protection and closing of the forest to work.

42. DEMMON, E. L. Fire in the southern pine forests. [New Orleans, La.,] 1932. 6p. mimeo. (U. S. Forest Serv. Southern Forest Expt. Sta.)

A résumé of present knowledge and studied opinion of this station on the relation of fire to growing pine timber in the South. This is stated under 23 numbered headings.

43. DEMMON, E. L. Fires and forest growth. illus. Amer. Forests 35(5): 273-276, 296. May 1929.

A popular article on results of fire damage studies conducted at the Southern Forest Experiment Station since 1921. Discussion includes effect of fire on seedlings, reproduction, height growth (with chart), turpentine yield, and a comparison of injury to shortleaf and longleaf stands.

44. DEMMON, E. L. Forest fires in the South. New Orleans, La., 1933. 316p. typewritten. illus. "Literature cited": p. 302-316. (U. S. Forest Serv. Southern Forest Expt. Sta.

Unpublished manuscript. Includes the effects of fire on immature and old-growth pines, on soil, on turpentined timber and a chapter on silvicultural uses of fire, covering 8 headings.

45. DEMMON, E. L. The silvicultural aspects of the forest-fire problem in the longleaf pine region. Jour. Forestry 33(3): 323-331. Mar. 1935.

A résumé of the fire problem in the longleaf pine region as it applies to silviculture. Headings are "Kinds of fires", "Factors influencing fires", "Effect of fire", "Controlled burning." The author concludes that no single set of recommendations for controlled burning can be set down for any area. Fire in the longleaf region is not always accompanied by damage and some are beneficial. The author indicates various points of the whole problem which still require research.

46. ELDREDGE, I. F. Administrative problems in fire control in the longleaf - slash pine region of the South. Jour. Forestry 33(3): 342-345. Mar. 1935.

The author points out that the old accepted complete protection policy must be scrutinized closely since it has not worked satisfactorily in the South. Further research is urged.

47. FISCHER, C. E. C. The need of fire-protection in the tropics. Indian Forester 38(5): 191-221. May 1912.

The author has attempted to collate all the literature up to 1912 on the value and harm of fire in India. "The present paper purports to quote, first, a few extracts showing the value of fire-protection in India, then at

considerable length the arguments on which the opposite theory is founded, and then to discuss the evidence pro and con, closing with suggestions for general conclusions." --from introd. Correspondence from E. A. Smythies commenting upon extracts used in this paper from his writings appears in Indian Forester 38(8): 406-408. Aug. 1912. Comments on the paper by H. C. Walker appear in Indian Forester 38(9): 437-452. Sept. 1912.

48. FISHER, W. R. Forest protection. In Schlich's manual of forestry, vol. 4. London, Bradbury, Agnew and co., 1895. 593p. illus.
Chapter 4 includes damage done to forests by various kinds of fires, and treatment of injured areas.

49. FOLWEILER, A. D. The effect of fire. illus. In his Theory and practice of forest fire protection in the United States. [Baton Rouge, La.] 1937. p. 15-28.
Includes a discussion of positive effects of fire under these headings: As a silvicultural tool; for protection against excessive damage; slash disposal; for forest game management; for modifying some soil characteristics. Negative effects of fire are discussed under these headings: Tree growth; soil-water relationships; soil composition and productivity; disease and insect attacks; human activity and mortality; wildlife. Includes section on light burning.

50. FORBES, R. D. Forest and grass fires in Louisiana; a private loss - a public calamity. [New Orleans, La.] 1918. 32p. illus. (La. Dept. Conservation. Bul. 6) Reviewed in Jour. Forestry 16(8): 930-933. Dec. 1918.
Injury to mature timber and young growth, to farm crops, wildlife and grazing.

51. FRITZ, Emanuel. The rôle of fire in the redwood region. Berkeley, Calif., 1932. 23p. illus. (Calif. Agr. Expt. Sta. Circ. 323)
Includes effects of fire on trees, composition of the forest, on reproduction and on the soil.

52. FRITZ, Emanuel. The rôle of fire in the redwood region. Jour. Forestry 29(6): 939-950. Oct. 1931.
Because the redwood is highly fire-resistant and the heavy stands obscure the extent of damage done by fire, its evil effects are not noted by the casual observer. The author discusses fire in relation to hollows, decay and spike-top in the redwood, and its destructive effect on the soil, young forest growth and tourist travel.

53. FROTHINGHAM, E. H. Timber growing and logging practice in the southern Appalachian region. Wash., Govt. print. off., 1931. 92p. illus. "Literature cited": p. 89-92. (U. S. Dept. Agr. Tech. Bul. 250)

Fire is the most destructive agency in this forest region. Composition of the forest is changed, due to the increase of hardwood sprouts following fire. Includes a discussion of loss of soil fertility through destruction of the leaf litter and resulting compacted soil and erosion, and decay and insect problem from fire-scarred standing timber. Tables show results of fire on reproduction of desirable and undesirable species.

54. GRAVES, H. S. Protection of forests from fire. Wash., Govt. print. off., 1910. 48p. illus. (U. S. Forest Serv. Bul. 82)

"Damage by fires", p. 12-17, discusses the problem under these headings: Death of trees; injury to trees; injury to the soil; reduction of density; effect on reproduction.

55. HANZLIK, E. J. Effects of fire on new forest growth described by a forester. illus. Four L Lumber News 10(13): 36. May 1928.

A popular article on destructive effects of various classes of fires upon standing timber, soil and reproduction.

56. HARPER, V. L. Fire research in the lower South. figs. Fire Control Notes (U. S. Forest Serv.) Aug. 9, 1937, p. 229-237.

"This article is adapted from a report prepared by the author pursuant to starting new studies in fire control at the Southern Station during 1937" - from introd. Includes problems in turpentining areas, and a short discussion of controlled burning as well as a section on the problem of evaluation of the silvicultural effects of fire.

57. HASTINGS, A. B. "Just brush." Charlottesville, Va., 1925. [6]p. illus. (Va. Forest Serv. Pub. 36)

How repeated burning perpetuates brush land and how such an area has been transformed into valuable forest land by fire protection by U. S. Forest Service in Virginia.

58. HAWLEY, R. C. Forest protection. N. Y., John Wiley and sons, 1937. 262p. References at end of chapters.

Chapter 8, p. 133-153 includes effects of fire, injurious and beneficial.

59. HOFMANN, J. V. How fires destroy our forests. illus. Amer. Forestry 26(318): 329-336. June 1920.

A popular presentation of results of research at the Wind River Experiment Station in the Pacific Northwest

on effects of fire. Elaborates upon the seven successive stages in the devastation of forests by repeated fires.

60. HÖGBOM, A. G. Om skogseldar förr och nu, och deras roll i skogarnas utvecklingshistoria. Uppsala och Stockholm, Almqvist Wiksells boktryckeri-a.-b. [1934]. 101p. illus. (Norrländskt handbibliotek XIII)
Forest fires, past and present, and their role in the development of forestry.

61. HOWARD, W. G. Damage done by fires. In his Forest fires, p. 10-12. (N. Y. Conservation Comm. Bul. 10)
Popular discussion of direct and indirect damage.

62. HOWE, C. D. Canada's forestry conditions and problems. illus. Illus. Canad. Forestry Mag. 18(5) : 765-766, 800-803. May 1922.
Effects of forest fires: 801-803.

63. HOWE, C. D. The effect of repeated forest fires upon the reproduction of commercial species in Peterborough county, Ontario. In Canada conservation comm. Forest protection in Canada 1913-1914. Toronto, 1915, p. 166-211. illus., map.
Description of conditions, with graphs, and charts, of areas burned once, areas burned twice, areas burned three times, and areas burned many times, showing effects upon the soil, commercial value of the forest future reproduction and erosion.

64. JACQUOT, André. Incendies en forêt (Forest fires); translated by C. E. C. Fischer. Calcutta, Govt. print., 1910. 278p. Reviewed in Indian Forester 32(4): 207-211. Apr. 1906.
Translation of the 2d edition (first published in 1904 by Berger Leverault, Paris and Nancy). This is the first book dealing comprehensively with forest fires to be published. It covers in great detail how to appraise damage in different types of forest. Chap. 6 (p. 196-232) is divided into 10 sections of injury by fire, direct and indirect.

65. LEAVITT, Clyde. Forest fires. In Rept. Nat'l. Conservation Comm. vol. 2, 1909. p. 390-468.
Includes destructive effects of forest fires on reproduction, standing timber, on composition and distribution of the forest, deterioration of forest soil, and injury to streamflow.

66. MARSH, G. P. Effects of forest fires. In his The earth as modified by human action. N. Y., Charles Scribner's sons, 1885. p. 350-356.
This chapter is a general discussion of fire and its effects. Pages 373-345 also contain related material.

67. MITCHELL, J. A. That "harmless" forest fire. Amer. Lumberman (2601): 76. Mar. 21, 1925.
Excerpts from U. S. D. A. Bulletin 1294, by Show and Kotok. (See entry 77)

68. MORRELL, Fred. Effects of fireon longleaf pine. Service Bul. (U. S. Forest Serv.) 16(22): 5-6. May 31, 1932.
Excerpts from a report by Austin Cary to a land company in Alabama on effect of summer fires, recovery after ordinary fires, and the effect of light annual winter fires on longleaf pine.

69. PEDERSON, F. C. The destruction caused by forest fires. Charlottesville, Va., [1930?] 16p. illus. (Va. Forest Serv. Pub. 42)
The adverse effects of fire and of repeated burning on forage, tree growth, reproduction, fish and game.

70. PINCHOT, Gifford. The effects of fire on forest production. In N. J. Geol. Surv. Ann. Rept., 1899. p. 103-123.
Forest fires damage the standing timber and injure or kill the young growth. In addition they destroy the humus layer necessary to protect the soil moisture. Because of repeated fires there is a lack of interest in forest protection. When the original stand of pine was cut it was followed by seedling and sprout oak and pine. As a result of fires the young stand produces timber fit only for cordwood, and only one-third the volume possible with protection and one-sixth the volume possible with careful management.

71. PINCHOT, Gifford. The relation of forests and forest fires. illus. Nat'l. Geographic 10(10): 393-403. Oct. 1899.
Vast loss from forest fires includes deterioration of the soil, damage of water supply, destruction of reproduction and loss in increment in young growth (which may reach loss of several hundred board feet per acre each year). Fire is probably the reason that much of the prairies is treeless. The article explains how fire is related to the composition of the forest stand, mentioning especially the western larch, the bigtree, longleaf pine, lodgepole pine and red fir.

72. PINCHOT, Gifford. A study of forest fires and wood production in southern New Jersey. Trenton, N. J., 1899. 102p. illus. (Appendix to annual report of the state geologist for 1898).

p. 17-27 cover the damage to standing timber, effect on cedar swamps, injury to young growth, and injury to the soil. p. 46-47 are on the ability of pitch pine to send up roots from dormant buds at the collar of the roots and to sprout at the crown after the foliage has been completely burned.

73. RENNE, Waldbrandfolgen im Lichte forstwierschaftlicher Erfahrungen (Consequences of forest fires in the light of silvicultural experience). Allg. Forst u. Jagd Ztg. 79: 143-148. May 1903.

The effect of forest fires on young and old conifers, larch, oak (shoots developing after fire), beech, birch and alder.

74. SAARI, Eino. Kuloista (Forest fires [in Finland with special reference to state forests]). tables. Acta Forestalia Fennica 26: 1-155. 1923. "Summary in English": 143-155.

Includes the extent and nature of damage from forest fires.

75. SCHWARZ, G. F. The longleaf pine in virgin forest; a silvical study. N. Y., John Wiley and sons, 1907. 135p. illus.

Chapter 4, "Fires", p. 47-88, illustrated with good photographs and a table, discusses harmful results of fire under 4 headings: Destruction of seed, especially in the fall of the year; injury of seedlings, in spite of their remarkable resistance; bark and bud injury to older trees; impoverishment of seed-bed and soil by repeated burnings.

76. SHOW, S. B., and Kotok, E. I. Fire and the forest (California pine region). Wash., Govt. print. off., 1925. 20p. illus. (U. S. Dept. Agr. Dept. Circ. 358)

"Observations in the California pine forests showed fire injury is cumulative, since scars of earlier fires serve as susceptible points of attack. Direct heat killing was noted to be most frequent in forests previously injured by fire. Species varied much in their resistance, followed in order by the sugar pine, white fir, and incense cedar. Fire scars apparently facilitated the entrance of insects and fungi. Reproduction suffered severely, as the young coniferous seedlings were easily killed. The ultimate result of repeated burnings is non-productive brush land, susceptible to erosion and of little value in the retention of moisture. Even the lightest of surface fires are a direct menace to the forest, despite popular notions to the contrary. The exclusion of fire would tend to encourage reproduction greatly." - Expt. Sta. Rec. 54(1): 43. Jan. 1926.

77. SHOW, S. B., and Kotok, E. I. The rôle of fire in the California pine forests. Wash., Govt. print. off., 1924. 80p. illus. "Literature cited": p. 80. (U. S. Dept. Agr. Dept. Bul. 1294)

Fire throughout the California pine region, in the virgin forests, in restocking brush fields, and on cut-over lands, is important not only for the loss in timber resources but also because it paves the way for more serious fires by allowing the invasion of inflammable brush species and by adding fuels in other forms. Fires in virgin forests are seldom catastrophic, but by attrition, repeated fires reduce the quality of the forest. This process is slowest in virgin forests, most rapid on brush fields. Includes a section on light burning. Though there may be beneficial uses of fire, the data show that the lightest fires contribute to destroying the value of the forests. The progress of forest management depends upon a thorough understanding of fire damage.

78. SLYM, M. J. Memorandum on jungle fires. Indian Forester 2(3): 270-280. Jan. 1877.

p. 274 lists injurious effects, after which the author shows some beneficial effects. Indian Forester 3(2): 162-163. Oct. 1877, contains a reply, signed N. A. U.

79. TAYLOR, W. L. The problem of fire in British forests. Forestry 4(2): 78-92. Dec. 1930.

Notes (p. 78-79) on primary and secondary damage done to forests by surface, sub-surface and crown fires.

80. U. S. FOREST SERVICE. Report on forestry [prepared by F. B. Hough and Nathaniel Eggleston]. Wash., Govt. print. off., 1878-1884. 4 vol. illus.

Material on damage from forest fires appears in vol. 1, p. 155-158; effects on forest succession, vol. 1, p. 190-193; prairies and barrens caused by annual burning, vol. 1, p. 489, 490 and 580; an historical account of Indian fires and the effects of fire upon reproduction, vol. 3, p. 224-228; relation of fire and insects, vol. 3, p. 242-245; a section on the possibility of the forest renewing itself in the prairies, vol. 4, 114-115.

81. U. S. FOREST SERVICE. When fire is banished from the land of the white oak. Wash., Govt. print. off., 1925. 10p. illus. (U. S. Dept. of Agr. Misc. Circ. 53)

Conditions in the Ozark National Forest, Arkansas. Covers damage to standing timber, to young growth and to watersheds.

82. U. S. FOREST SERVICE. Woods burning in the South. Wash., Govt. print. off., issued May 1929; rev. Sept. 1936. 4p. illus. (U. S. Dept. Agr. Leaf. 40)

A warning against woods burning and a plea for cooperation in developing an adequate fire protection system in the South.

83. WAHLENBERG, W. G. Effect of annual burning on thickness of bark in second growth longleaf pine stands at McNeill, Miss. Jour. Forestry 34(1): 79-81. Jan. 1936.

"One hundred trees were measured in each of 7 diameter classes and from each of 2 conditions--unburned for 10 years and annually burned for 10 years. Both stands were established and grew in previous years under conditions of annual or frequent periodic grass fires. The trees were from 15 to 20 years old at a point 6 inches above the ground. The bark was thicker on the trees in the unburned stand than those in the annually burned stand by an average difference of 0.029 inches for all diameter classes measured." - from p. 80.

84. WAHLENBERG, W. G. Effect of fire on grazing and soil properties and the natural reproduction of longleaf pine. "References": p. 337. Jour. Forestry 33(3): 331-337. Mar. 1935.

Experiments carried on at McNeill, Mississippi, indicated that exclusion of fire benefited the soil physically, but that frequent burning benefited the soil chemically. The effect of annual burning on longleaf pine cone production was negligible. Both annual burning and complete exclusion of fire have proved unsatisfactory. Periodic light silvicultural burning is indicated as a means of assisting longleaf pine seedlings to emerge from the grass, but further investigations are needed, and the effect of fire upon growth retardation after the seedling stage is still in the experimental stage and requires more study.

85. WAHLENBERG, W. G., Greene, S. W., and Reed, H. R. Timber growing and cattle grazing on longleaf pine lands. 1938. 149p. "Literature cited": 132-141. typewritten, illus.

Unpublished. (To be issued as a U. S. Dept. Agr. Tech. Bul.) Contents include effects of burning and grazing on longleaf pine stands; effects of burning, grazing and tree competition on forage; effects of burning and grazing on the soil.

86. WALKER, H. C. Fire-protection in Burma. Indian Forester 34(6): 339-349. June 1908.

This author holds that the arguments used by fire protectionists in India are unsound, and advocates the abandonment of protection in the teak forests of Burma for the present, at least.

87. WHITAKER, J. R. Protection from forest fires. In Our natural resources and their conservation; by Parkins, A. E., and Whitaker, J. R. N. Y., John Wiley and sons, 1936. p. 262-271.

A general chapter covering briefly the effects of fire, with a footnote on p. 267 on use of controlled burning by skilled foresters.

88. WHITFORD, H. N. [Comments on] Forests and human progress. Jour. Forestry 19(1): 58-64. Jan. 1921.

Comments on article by Raphael Zon which appeared in the Geographical Review, 10:139-166. 1920. (See entry 91) Mr. Whitford stresses the importance of fire in destroying forests and influencing civilization, citing the Mayan decline and the system of burning land for agricultural purposes in tropical countries.

89. WHITTLE, C. A. Why prevent woods fires? [Atlanta, Ga., 1930] 11p. illus. (Ga. Forest Serv. Leaf. 7)

A popular discussion of 8 destructive effects of fire, with special reference to southern conditions.

90. WOLCOTT, R. H. Fires in relation to the biota. In Naturalists' guide to the Americas. Baltimore, Williams and Wilkins co., 1926, p. 34-38.

A succinct comprehensive summary of the detrimental effects of fire on plants, soil fertility and wildlife. Mentions beneficial effects attributed to fire, including improvement of soil nutrients,and shows that upon investigation the damaging results of fire outweigh the beneficial results. One section is on relation of fire to forest succession.

91. ZON, Raphael. Forests and human progress. Geogr. Rev. 10(3): 139-166. Sept. 1920.

Includes the effect of fire in changing the composition of the forest in Michigan, Rocky mountains and Sweden. The author holds that caingin making (agricultural methods using fire, adopted in the Philippines) could never bring about destruction of the forest. (p. 153-154)

EFFECT ON FOREST SUCCESSION

(See also entries 1, 18, 21, 22, 174, 175, 215, 269, 276, 306, 312, 491, 514, 585)

92. ALDERMAN, O. A. Some effects of fire on pine hardwood forests in southeastern Ohio. tables. Ohio. Agr. Expt. Sta. Mo. Bul. 10(5/6): 93-95. May/June 1925.
The effects of fire in disturbing natural forest succession. Oak-pine and white pine-aspen associations are discussed in some detail.

93. BROUSE, E. F. How fire changes forest types. tables. Jour. Forestry 22(6): 43-51. Oct. 1924.
A discussion of 7 points in connection with fire as a disturbing agency in natural forest succession, and the results of one burn and frequent burns on a forest. Paper read at the Allegheny section of the S. A. F. at Harrisburg, Pa., Feb. 29, 1924.

94. CABIANCA, Silvio. The regeneration of forests damaged by fire. "Publications consulted": p. 194. Int. Rev. Agr. Mo. Bul. Agr. Sci. and Pract. 23(5): 190-194. May 1932.
Abstracts of the findings of 8 other workers on the indirect destructive effects of fire, with special emphasis upon regeneration and succession.

95. CARY, Austin. White pine and fire. Jour. Forestry 34(1): 62-65. Jan. 1936.
Comments on article by D. K. Maissurow (See entry 129) and personal observations on the agency of fire in producing the northern white pine forests of the Northeast and Lake States, and a note on fire and longleaf pine.

96. CHAPMAN, H. H. Is the longleaf type a climax? "Bibliography": p. 334. Ecology 13(4): 328-334. Oct. 1932.
"Stands of Pinus palustris on sandy soil of the southern coastal plain are often practically pure and show an adjustment to environmental conditions and an equilibrium characteristic of climax associations. Such forests possess a grassy floor which seems to have been burned over at intervals of 3-5 years. This pine is very resistant to such fires, since during the 1st 5 years from seed it develops an extensive root system but no aerial system, and by the end of the second five years its trunks will withstand considerable fire without injury. Evidence is presented that such frequent burning favors the development of the longleaf climax forests as they now exist and is necessary for the best development of P. palustris. Among other advantages to the pine of such frequent fires

is the control of a needle blight caused by Septoria acicola which is very destructive to seedlings less than 1 m. high." - G. D. Fuller, in Biol. Abs. 7(5): 1038. May 1933.

97. COLGAN, Nathaniel. The burnt ground flora of Killiney Hill. Irish Naturalist 21: 72-76. April 1912.
Observations 2 to 3 months after destruction of the flora of this area by fire showed that 11 species made their appearance, but no evidence for or against the theory that their seeds had survived the fire. The area was formerly densely covered with gorse.

98. COLGAN, Nathaniel. Further notes on the burnt ground flora of Killiney Hill. Irish Naturalist 22: 85-93. May 1913.
Observations made 14 to 18 months after fire in a gorse covered hill near Dublin which destroyed all flora, revealed 64 species on the ground, 45 immigrants, 13 survivals and 6 of doubtful origin. The author notes the subordinate part of surviving plants in the new vegetation and speculates as to possibility of reversion to the pre-fire conditions.

99. DUCAMP, Roger. Au pays des incendies (In the country of forest fires). Rev. Eaux et Forêts 70(5): 380-393. May 1932.
A report on a trip through Provence. How fires have unfavorably influenced forest succession, and suggested means to improve conditions in the region.

100. DUFOUR, Leon. Causes de l'apparition, en grande abondance, de certains champignons à la suite d'un incendie de forêt (Causes of the appearance of mushrooms following a forest fire). Bul. Soc. Mycol. (France.) 38(2): 93-97. 1922.
Includes the sterilizing effect of the fire on the soil and reasons why certain types of vegetation, previously not on an area, spring up after fire.

101. GALBRAITH, J. Forest regeneration in Gippsland. Victoria Nat. 43(2): 53-56. 1926.
Includes notes on the early woody and herbaceous flora following a forest fire in 1923.

102. GARMAN, E. H. Natural reproduction following fires in central British Columbia. Forestry Chron. 5(3): 28-44. Sept. 1929.
Results of a study on the upper Fraser River in spruce-balsam and cedar-spruce forest types, using 17 sample plots. Aspen replaced fireweed to form the first forest cover after fire. Reproduction was unsatisfactory. There was no degree of correlation between degree of restocking

and the age of a burn. Extracts from the article entitled "New forests that follow fire" appear in Illus. Canad. Forest and Outdoors 27(9): 33-34. Sept. 1931.

103. GILMORE, J. D. First steps in forest management. Jour. Forestry 23(7/8): 617-625. July/Aug. 1925.
Includes reproduction studies in Newfoundland 14 years after a fire in balsam-spruce stands which are analogous to the hemlock-Douglas fir stands on the Pacific Coast. If such areas are properly burned over immediately after logging the result is a stand of Douglas fir; with protection, the result is hemlock, a less desirable species. Similarly, in Newfoundland, with protection, the result is balsam; with proper light burning, the result is spruce.

104. GODWIN, H. The Fen fire of 1929 and its effect on vegetation. In The natural history of Wicken Fen, by J. S. Gardner. Cambridge, Bowes and Bowes, 1932, pt. 6, p. 595-600. illus.
Abstracted in Biol. Abs. (5): 1038. May 1933.

105. GRAFF, P. W. Invasion of Marchantia polymorpha following forest fires. "Literature cited": p. 74. Bul. Torrey Bot. Club 63(2): 67-74. Feb. 1936.
Includes effect of fire upon natural forest succession in the West, and reversion of certain areas to grassland type of vegetation.

106. GRAFF, P. W. Plant invasion following fires. Torreya 35(6): 137-141. Nov./Dec. 1935.
About certain plants which spring up on burned areas, and on the usual change of succession which develops until the earlier natural type reappears. Discusses the lodgepole pine in the West as it persists until it is replaced by Douglas fir and larch.

107. GREENE, S. W. The forest that fire made. illus. Amer. Forests 37(10): 583-584, 618. Oct. 1931.
The author holds that the longleaf forests of the South are the result of long years of grass fires, and that continued fires are essential to the perpetuation of the species as a type.

108. HARPER, R. M. Economic botany of Alabama. Part 1. [Montgomery, Ala.,] 1913. 228p. illus. (Ala. Geol. Surv. Monograph 8)
Material on the effect of fire upon the longleaf pine forest type appears on p. 25-27. The author asserts that this type owes its origin to fire, and if protected completely (which is not possible) the tree would become

extinct. In the mixed pine and oak woods, fire, even if it does not harm the trees, impoverishes the soil. Excerpts from the monograph appear under title "A defence of forest fires" in Literary Digest 47(6) "whole no. 1216): 208. Aug. 9, 1913.

109. HARPER, R. M. The forest resources of Alabama. Amer. Forests 19(10): 657-670. Oct. 1913.
An elaboration of the author's conclusions on effect of fire in the longleaf pine type which was noted in the preceding entry.

110. HARPER, R. M. The relation of climax vegetation to islands and peninsulas. Bul. Torrey Bot. Club. 38(11): 515-525. Dec. 1911.
The author attributes the vast difference in the hammock vegetation on the islands and peninsulas in Lake Tsala Apopka, Florida, and that of the neighboring high pine land to fire.

111. HARSHBERGER, J. W. The vegetation of the New Jersey pine-barrens; an ecologic investigation. Philadelphia, Christopher Sower co., 1916. 329p. illus. fold. map.
The influence that fire had in the origin and perpetuation of this plains vegetation, p. 167-170. Quotation from Gifford Pinchot, to the effect that fire and hardpan account, in large part, for the present conditions, p. 159-160.

112. HESMER, Herbert. Zur Frage des Aufbaues und der Verjüngung europäischer Urwälder (On the question of the development and regeneration of European virgin forests). Forstarchiv 6(14): 265-274. July 15, 1930.
The author concludes that forest fires have no direct influence on the structure and composition of virgin forests, nor do they exercise a definite influence on the change of forest tree species.

114. HUBERMAN, M. A. The role of western white pine in forest succession in northern Idaho. illus. "Literature cited": p. 150-151. Ecology 16(2): 137-151. April 1935.
Includes sections on "human influence and fire", and the successional sequence following fire in this type.

115. HUMBERT, Henri. La destruction d'une flore insulaire par le feu: principaux aspects de la végétation à Madagascar. illus. Mém. Acad. Malgache 5: 1-79. 1927.
"Much of the forest destruction has resulted from the practice of a primitive type of agriculture (tavy) in which the forest is slashed, burned over, cropped for a

very few seasons and then abandoned. Other accidental and incendiary fires have aided in the disappearance of the forest. The forest has been replaced by grasses and scrub, and these have also been subject to frequent fires. The resulting prairie, scrub and semi desert are described and illustrated by photographs." - from G. D. Fuller, in Biol. Abs. 7(5): 1039. May 1933.

116. HUMBERT, Henri. La disparition des forêts à Madagascar, ses causes, ses conséquences (The disappearance of the forests in Madagascar, its causes, consequences). illus. Rev. Gén. Sci. Pures et Appl. 37(11): 325-336. 1927.
"The natives cut down and burn over a piece of the forest each year in order to make room for growing rice and other food plants; exploited forests are burned after removal of the valuable timber; and prairie fires started by the natives to obtain young growth for their cattle eat gradually into the forests.... In a constantly humid climate the destroyed forest is replaced by savoka and finally, after repeated burnings of the savoka, by prairie. Where there is a decidedly dry season prairie or savannah follows the destroyed forest without the intervention of savoka. In an arid climate the vegetation consists chiefly of shrubby Euphorbias which are little affected by fire. The remaining primeval forest is smaller than the savoka. It is proposed to prohibit the natives from burning new forest each year, and also from ruthlessly exploiting the forest, and to restrict burning of the prairies, at least near the forest..." - from A. Rehder, in Biol. Abs. 5(3): 880. March 1931.

117. HUMBERT, Henri. Végétation des hautes montagnes de Madagascar (Vegetation of the high mountains of Madagascar). In Peuplement des hautes montagnes.) Mém. Soc. Biogéogr. [Paris] 2:195-220. 1928.
"...Repeated fires have had a disastrous effect upon the vegetation, especially the endemic sp. A burnt forest is generally replaced first by shrubby growth, dominated by Ericacae and Compositae. When this growth is burned in turn, it is replaced by sclerophyllous Gramineae, the final type of vegetation thus being a prairie..." - from author's summary, in Biol. Abs. 6(6/7): 1577. June/July 1932.

118. JARRETT, P. H., and Petrie, A. H. K. The vegetation of the Blacks' Spur region. A study in the ecology of some Australian mountain Eucalyptus forests. II. Pyric succession. illus. Jour. Ecology 17(2): 249-281. 1929.
"The succession in the Eucalyptus forests of the area following fires may be divided into denudation, destruction and survival, renascence, survival of seeds,

aggregation, migration, and establishment.... The forest fire must be regarded as a great simplifying factor in the development of these communities, which has led to the elimination of types not possessing powers of rapid regeneration. Fires too, have considerably modified the structure of the communities, leading to increased density and purity, and to greater equality of age among the components. All adaptations whereby these plants regenerate, however, were existent before fires became a factor of the environment, and can be regarded in no way as special responses for pyric regenerations." from author's summary, in Biol. Abs. 8(2): 313. Feb. 1934.

119. KITTREDGE, Joseph, Jr., and Chittenden, A. K. Oak forests of northern Michigan. East Lansing, 1929. 47p. illus. (Mich. Agr. Expt. Sta. Spec. Bul. 190)

"...Natural conversion of oak back to pine is taking place only on a limited area due to the absence of seed pines as a result of repeated fires... Effective fire protection is essential for the upbuilding of the soil, to improve the growth of oaks, and make possible the conversion of oak to pine, whether by natural means or by planting..." - J. W. Wellington (courtesy Expt. Sta. Rec.) in Biol. Abs. 4(7/9): 2105. July/Sept. 1930.

120. KORSTIAN, C. F. Perpetuation of spruce on cut-over and burned lands in the higher southern Appalachian mountains. illus. "Bibliography", p. 166-167. Ecological Monographs 7(1): 125-167. Jan. 1937. Abstracted in Biol. Abs. 11(8): 2074. Nov. 1937.

The immediate effects of fire are discussed, including destruction of the organic matter and the micro-organisms of the upper soil layer, and erosion. The natural forest succession following fire in the region is traced, followed by a discussion of once-burned and twice-burned area.

121. KOTOK, E. I. Fire, a major ecological factor in the pine region of California. Proc. Pac. Sci. Cong., 5th (Canada) 5: 4017-4022. 1933. (1934)

A comprehensive paper on the significance of fire in forest succession. Direct and indirect results of fire are discussed, with special emphasis on conditions in the West.

122. KUJALA, Viljo. Untersuchungen über den Einfluss von Waldbränden auf die Waldvegetation in Nord-Finnland (Influence of forest fires on forest vegetation in north Finland). "Zitierte literatur": p. 37. Metsatieteellisen koelaitoksen Julkaisuja. Meddel. fr. Forstvetenskapliga forsoksanstalten. Communicationes ex Instituto

quaestionum forestalium Finlandiae, no. 10, p. 1-37. 1926. illus. Abstracted in Expt. Sta. Rec. 57(1): 46. June 1927.

Article is in German. Typewritten translation of summary is in the U. S. Forest Service Library.

123. LARSEN, J. A. Fires and forest succession in the Bitterroot mountains of northern Idaho. Ecology 10(1): 67-76. Jan. 1929.

"Intense forest fires which kill all trees and seedlings occur in the Bitterroot mountains. Plant successions which follow destruction of the climax association of Thuja plicata-Tsuga heterophylla-Abies grandis have been studied. The Pinus murrayana-Larix occidentalis association usually represents the first stage of succession after severe fires. With improvement of the site the Pseudotsuga taxifolia-Pinus monticola association develops, representing the second successional stage. Eventually, the climax association develops and represents the third and final stage. Each successional stage has its own distinct subordinate vegetation." - H. J. Lutz, in Biol. Abs. 4(6): 1646. June 1930.

124. LEOPOLD, Aldo. Grass, brush, timber, and fire in southern Arizona. Jour. Forestry 22(6): 1-10. Oct. 1924.

The rôle of fire in this area in connection with widespread abnormal erosion, and juniper reproduction merging with pine reproduction, and brush (including manzanita, mountain mahogany, and oak), which has, the author says, "taken the country."

125. LODGEPOLE pine plays Samaritan in northern Rockies. Forest Worker (U. S. Forest Serv.) Nov. 1924, p. 58-59.

Explanation of why, after fire in this region, lodgepole pine reproduction rapidly covers the burn and is the predominate species in the new forest, even when in the original forest this species was outnumbered 100 to 1 by other species of trees.

126. LONG, E. C. Forest fires in the southern pines. Forest Leaves 2(6): 94. Aug.-Sept. 1889.

"Annual burning...is the prime cause and preserver of the grand forests of Pinus palustris."

127. LONG, E. C. Notes of some of the forest features of Florida, with items of tree growth in that state. Proc. Amer. Forestry Cong. 7:38-41. 1888.

Includes reasons why the author believes that annual woods burning has originated and perpetuated the P. palustris type in the South and how, without fire, it is choked out by hardwood brush.

128. LUTZ, H. J. Ecological relations in the pitch pine plains of southern New Jersey. New Haven, 1934. 80p. illus. plates. (Yale Univ. School of Forestry. Bul. 38)

"Pyric and anthropeic relations as causative factors", p. 51-63, presents evidence that fire is of overwhelming importance in determining the character of the Plains plant community.

129. MAISSUROW, D. K. Fire as a necessary factor in the perpetuation of white pine. Jour. Forestry 33(4): 373-378. April 1935.

Results of two studies made on natural regeneration of white pine in relation to fire. (1) Period from 1850-1930, when natural regeneration was affected by logging. (2) Period from 1700-1850 when the virgin forest developed untouched, when natural reproduction was affected by the same factors which influenced it during logging, the greatest of which was fire. Silvicultural implications are that the pure white pine stands disappeared not by forest fires and not directly because of logging, but by a disturbed balance between seed-bearing capacity and frequency or destructiveness of forest fires. If logging operations create conditions existing on areas burned over, properly timed with seed years, white pine stands will reestablish themselves naturally. See entry 95 for comments, by Austin Cary.

130. MELECHOW, J. S. Zur Frage der natürlichen Verjüngung der Fichte auf Brandflächen. illus. Forstwiss. Centralbl. 56(2): 47-61. 1934.

"Recent investigations in northern U.S.S.R. refute the theory that spruce will reoccupy old burns only after the establishment of pioneer spp. such as birch, aspen, and pine. The spruce seedlings (24,450 out of a total 86,310 of all kinds per ha.) were mostly 7-13 years old. (1916-1922 germination), but some came in immediately after the fire. Most of the birch was 3-10 yrs. old, and very little of it came in before 1919. The final stand will be practically even-aged spruce (Picea obovata). The number of spruce seedlings per unit area increased with percentage of area covered with forest debris (stumps, logs, tops, etc.) up to about 40 per cent beyond which point it decreased..." - W. N. Sparhawk, in Biol. Abs. 8(6): 1547. June/July 1934.

131. MÜLLER. Aus der Entwickelungsgeschichte der ostpreussischen Forstwirtschaft (Development of forestry in East Prussia). Deutsch. Forstztg. 41(30): 777-781. 1926.

"Several centuries of uncontrolled burning and excessive unregulated cutting had by 1840 transformed the

original forest, which was predominantly a mixture of conifers and broadleaved trees, into one in which conifers occupied 75 per cent of the area..." - from W. N. Sparhawk, in Biol. Abs. 2(1/2): 259. Jan./Feb. 1928.

132. MÜLLER, K. M. Afbau, Wuchs, und Verjüngung der Südosteuropäischen Urwälder (Composition, growth and regeneration of the virgin forests in southeastern Europe). Hannover, M. and H. Schaper, 1929. 322p. illus. pl., maps. Reviewed by A. B. Recknagel in Jour. Forestry 28(5): 744-745. May 1930. Abstracted by W. N. Sparhawk, in Biol. Abs. 5(4): 1163. Apr. 1931. Abstracted by N. W. Hosley, in Biol. Abs. 5(6/7): 1780. June/July 1931. See also Stickel, P. W. (Entry 145)

Virgin forests are the result of some catastrophe such as a great fire which seems to regenerate it and save it from stagnation. In general, fires serve to purge the forest of insect and fungus enemies and to restore vigorous, fast-growing, light-demanding species. The author holds, with various Finnish foresters, that fire is a valuable silvicultural tool in stands with excess raw humus. Fire has become a recognized means of regenerating forests in Finland. Translation by C. P. de Blumenthal is in Forest Service Library.

133. PETERS, Richard. Changes of timber and plants. Races of animals extinct. Mem. Phila. Soc. Promoting Agr. 1:296-309. 1808.

Includes letters written to the author by Rembrandt Peale and Charles Caldwell on plant succession, stressing the rôle of fire in changing vegetative types.

134. PETERS, Richard. Departure of southern pine timber, a proof of the tendency in nature to a change of products on the same soil. Mem. Phila. Soc. Promoting Agr. 1: 27-40. 1808.

On the succession and changes of plants and animals throughout the world, with a note on the custom of firing the woods, which the author calls atrocious and ruinous, changing the type of vegetation.

135. PETERS, Richard. Herbage and shrubs spontaneously produced, after forest timber burnt, by firing the woods. Mem. Phila. Soc. Promoting Agr. 1: 237-239. 1808.

Strawberries grew up in profusion following burning of pine timber in Southampton county, according to the natives, and after several years a new growth of pine banished them.

136. PETTERSSON, Bror. Notes on the first stages of flora on burnt ground. "Literature cited": p. 138-139. Memoranda Societatis pro Fauna et Flora Fennica. 7(2): 119-139. 1931.

Results of investigations made near Helsingfors on small burned areas caused by camp fires. "...They make clear that (1) the bulk of the first appearing plants according to their species number, as well as to the abundancy of their records, are anemochores (2) that among them especially the species with dust-like and hair- or parachute-equipped diaspores dominate (3) that the zoochores are very scarcely represented and (4) also the species without any regular dispersal means." - from summary, p. 138. Contains bibliography.

137. PFLUEGER, O. W. The "kaiñgin" problem in the Philippines and a possible method of control. Jour. Forestry 28(1): 66-71. Jan. 1930. Abstracted by P. C. Wakeley in Biol. Abs. 5(2): 387. Feb. 1931.

Kaiñgin is the tropical practice of cutting trees and brush on an area and burning it, to prepare the ground for a crop, usually using the area only one season. This practice among most primitive tropical people accounts for such a large amount of "brush" instead of forest, because the fire kills tree reproduction, but does not destroy rank grass and other plants. The article quotes freely from other writers on the practice in the Philippines, Belgian Congo, and Burma.

138. RUBNER, Konrad. Die forstlich-pflanzengeographischen Verhältnisse des nördlichen Fenoskandiens (Forest and phytogeographic conditions of northern Fenno-scandia). illus. Forstwiss. Centralbl. 71(6): 185-211; (7): 225-245. 1927.

"In Lapland the northern limit of the forest has been gradually pushed southward by frequent fires, cutting and reindeer grazing..." - from Biol. Abs. 2(1/2): 261. Jan./Feb. 1928.

139. SHOW, S. B. The management of forest properties in the California pine region as a problem in applied ecology. illus. Sci. Mo. 19(5): 548-551. Nov. 1924.

Includes the importance of fire in influencing succession in the California coniferous forests.

140. SHOW, S. B. Modifications in forests of the Pacific slope due to human agencies. Jour. Forestry 24(5): 500-506. May 1926.

"The author summarizes the effects of fire, especially the extensive man-caused fires of recent times, and of the recent methods of steam logging, on the Douglas fir forests of Washington and Oregon, the white pine forests

of northern Idaho and Montana, and the western yellow pine forests of California." - P. C. Wakeley, in Biol. Abs. 1(6): 934. Oct. 1927.

141. SKUTCH, A. F. Early stages of plant succession following forest fires. "Literature cited": p. 189-190. Ecology 10(2): 177-190. April 1929. Abstracted in Biol. Abs. 4(4): 1020. Apr. 1930.

Observations on areas devastated by fire in Maine on the Blue Mountain Peak, Jamaica. Includes notes on certain fungi typical of burnt areas. Birches produce shoots after a fire more rapidly than any of its associated species.

142. STALLARD, Harvey. Secondary succession in the climax forest formations of northern Minnesota. illus. "Literature cited": p. 547. Ecology 10(4): 476-547. Oct. 1929.

Summary of the effects of fire, p. 545: "Fire has been the most universal and frequent agent of destruction, destroying not only the upland vegetation but that of the bogs as well. Fire in a dry season, by causing burn-outs in a bog, which later becomes filled with water, indicates a succession similar to that started by flooding. Repeated burning on any soil, except on rock outcrops, will produce a grass stage, although in bogs deep burning starts a reed or rush associes. Fire may totally destroy a bog or the organic soil of rock outcrops, thus starting succession at almost primary conditions, hydroseral in the former case, xeroseral in the latter. The grass stage of the mesophytic and dry areas is invariably followed by sumac, except in very dry outwash plains, when it may then be invaded directly by jack pine..."

143. STEVENSON, D. D., and Lei, P. F. Some effects of fire on the vegetation of the Loh Fau region of Kwangtung. illus. "References": p. 466-467. Lingnan Sci. Jour. 16(3): 463-468. July 1937.

Scene of a fire in the pinus type of vegetation covering about four acres was revisited six months after the fire and the effects of notes as: (1) gradual leveling the vegetation to a single type composed of scrub and coarse grasses and complete elimination of the native pine, and (2) progressive deterioration of the site.

144. STICKEL, P. W. Forest fires and their effects upon the forest types in the southern Appalachian mountains. Empire Forester (N. Y. State Coll. Forestry) 9(1): 56-59. 1923.

In the spruce type of the southern Appalachians, where logging is followed by fire, we find dense blackberry thickets, and a few inferior species of trees. On the

dry slope and ridge type, fire may favor the pines, but undoubtedly the stand deteriorates by the introduction of weed species. In the upper moist slope type fire results in a dense sprout forest of little value until thinned. In the lower moist slope and cool type, fire appeared to be beneficial.

145. STICKEL, P. W. Old-growth forests of southeastern Europe. "Literature cited": p. 21. Forest Worker (U. S. Forest. Serv.) 8(2): 18-21. March 1932.

K. M. Müller's volume on virgin forests of Europe (See entry 132) is reviewed, abstracted and evaluated for American foresters, with special emphasis on the rôle of fire in silviculture. The application of methods involving the use of fire in regeneration of certain types of U. S. forests is suggested for study, and the findings of other foresters along this subject are cited.

146. SWENSON, O. F. Forest types and their relations to burns on the Gila national forest. illus. Nebr. Univ. Forest Club Annual 3:20-29. 1911.

Five forest types of the Southwest and the effect of fire on succession of each type.

147. TORREY, R. H. Another report of Marchantia polymorpha after forest fires. Torreya 32(5): 128-129. Sept./Oct. 1932.

Includes a letter by W. H. Diehl of the Bureau of Plant Industry on Marchantia as an early comer after a fire, and a further note by the author on the sudden and widespread seizure of open areas of charred humus and their mineral soil of Marchantia on Rittatiny mountain in New Jersey.

148. TORREY, R. H. Marchantia polymorpha after forest fires. Torreya 32(1): 9-10. Jan./Feb. 1932.

Notes the appearance of this liverwort growing in mats over burned areas. The author surmises that it helps to renew the burned humus and to prepare the soil again for other plants.

149. U. S. FOREST SERVICE. Lake States forest experiment station. Effect of spring fires on sprout oak stands. St. Paul, Minn., 1936. 1p. processed. (Tech. Note 120)

Burning experiments at the Michigan Forest Fire Experiment Station at Roscommon, Michigan, show that (1) practically all trees and sprouts under 4" were killed back. (2) All larger oaks surviving were severely damaged. (3) Conifers were eliminated. (4) Oaks (trees and sprout clumps) and aspen stems increased. (5) Aspen replaced oak as a dominant species. (6) Total number of trees and sprout clumps doubled.

150. U. S. FOREST SERVICE. Lake States forest experiment station. Fire hinders conversion of aspen to pine and spruce. St. Paul, Minn., 1931. 1p. mimeo. (Tech. Note 34)
An area of forest land predominately of aspen cover was burned and planted to pine and spruce in a study to determine if burning would hasten the conversion of the aspen forest into the other more valuable species. The burning stimulated aspen suckers, which are competitors of pine and spruce.

151. VORREITH. Die Wiederbestandbringung der entwaldeten obersten Berglagen in den Alpen (Reforestation of the deforested upper slopes in the Alps). Wiener Allg. Forst u. Jagd Ztg. 47(30): 176-178; (31): 182-183. 1929.
"The downward recession of timber line in the Alps is due principally to human agencies. Site conditions resulting from cutting, grazing and fire prevent natural regeneration of the forest, which is replaced by grass or by Vaccinium, Rhododendron, and heather..." - from F. S. Baker, in Biol. Abs. 4(7/9): 2107, July/Sept. 1930.

EFFECT ON GRASSLAND SUCCESSION

(See also "Historical", "Effect on Forest Succession", "Effect on Ranges and Pastures", and entries 97, 98, 105, 111, 115, 128, 143, 151, 431.)

152. CAMPBELL, R. H. Why the prairies are treeless. illus. Illus. Canad. Forestry Mag. 17(1): 5-8. Jan. 1921.
Quotes from H. Y. Hind, (1859) and John Macoun, (1902) showing that fire caused the prairies.

153. COCKAYNE, L. An economic investigation of the montane tussock-grassland of New Zealand. XI. The grassland of the Humboldt mountains established since the burning of their forest covering. illus. New Zealand Jour. Agr. 23(3): 137-147. Sept. 1921.
A study made of an area after the occurrence of two fires which left the ground surface similar to that after logging and clear burning of slash, and the natural and artificial resultant vegetation (exclusive of forest regeneration).

154. FRITSCH, F. E. The heath association on Hindhead Common, 1910-1926. illus. Jour. Ecology 15(2): 344-372. 1927.
Gives in detail succession after fires on Hindhead Common, S. W. Surrey, England, and many adjacent parts of Surrey. "The results tend to emphasize the stationary character of such heath vegetation. Fires cause little ultimate change and, after a number of years, the heath

presents the same appearance and detailed composition as before." - from author's summary, in Biol. Abs. 8(2): 312. Feb. 1934.

155. GASKILL, Alfred. Why prairies are treeless. Proc. Soc. Amer. Foresters 1(3): 158-178. Apr. 1906.
The author summarizes 7 theories which have been advanced as to the origin of the prairies, and then presents his own theory, that the prairies were caused by fire, supporting it with evidence he has gathered from geology, physiography, climatology, and botany.

156. GLEASON, H. A. An isolated prairie grove and its phytogeographical significance. Bot. Gazette 53(1): 38-49. Jan. 1912.
Includes remarks on the rôle of fire as the chief and probably the only agent in the removal of forests from moraines and other areas in the prairies not protected by a water barrier.

157. GLEASON, H. A. The relation of forest distribution and prairie fires in the Middle West. Torreya 13(8): 173-181. Aug. 1913. (Contrib. 141 from the Botanical Laboratory, University of Chicago)
The location of forests in central and northern Illinois and adjacent areas is closely correlated with prairie fires. Effects of fires from the east were negligible, but those coming from the west have been the determining factor in the distribution of the forests. "With prairie fires eliminated, the forest is naturally dominant, and tends to spread over wider areas at the expense of the prairie. Under the attack of prairie fires, the forests have been driven back or destroyed, except in those areas where the favor of morainic or fluviatile topography has enabled them to resist the encroachments of the prairie." --from body of the article.

158. JEPSON, W. L. The rôle of fire in relation to the differentiation of species in the chaparral. In Inter. Bot. Cong., 5th, Cambridge, 1930 (1931) [part of] Sec. E, Phytogeography and ecology, p. 48-181.
The entire section is abstracted in Biol. Abs. 8(2): 310. Feb. 1934.

159. [MEEHAN, Thomas] Treeless prairies. Bot. Gazette 6(8): 253-255. Aug. 1881.
An extract from the Proc. of the Phil. Acad. (no date given) about a paper by Thomas Meehan, attributing the lack of trees on the prairie to annual burning. Includes opinions of early geologists, botanists, and other research men concerning this theory.

160. MICHELL, M. R. Some observations on the effects of bush fires on the vegetation of Signal Hill. illus. "Literature cited": p. 232. Trans. Roy. Soc. South Africa. 10(4): 213-232. 1922.

The effects of a 2-day fire which killed all the aerial parts of all the plants in the area. Burning favors the spread of "Rhenoster bush" (Elytropappus rhinocerotis). Three suggestions as to how fire may influence the soil and thus benefit plants are given. An adverse effect upon the soil on slopes is causing erosion, by denudation in this area.

161. MYERS, J. G. Observations on a journey from the mouth of the Amazon to Mt. Roraima and down the cattle-trail to Georgetown. Agr. Jour. Brit. Guiana 5(2): 86-100. 1934.

Includes the author's opinion that overgrazing has deteriorated pasture lands of this region, and that fires do not interfere with the value or composition of savanna vegetation.

162. PERRIER de la Bathie, H. Les prairies de Madagascar. (The prairies of Madagascar). Rev. Bot. Appl. Agr. Coloniale 8(84/86): 549-557, 631-642. 1928.

"The successive degradations have tended to produce formations of grasses unsuited for nourishment of cattle. The origin of the prairies, their successions, and their degradation have only one cause: the inveterate habit of the Malagassi of lighting savage fires (fire uncontrollable) which, started without well defined reason, destroy each year all the vegetative cover. These fires denude the unfertile expanses just before the great rains of winter, slowly impoverish the soil, and gradually change the country into a desert..." - from author's summary (transl. by R. A. Dobbins), in Biol. Abs. 3(9/11): 1646. Sept./Nov. 1929.

163. PHILLIPS, J. F. V. Fire: its influence on biotic communities and physical factors in South and East Africa. South African Jour. Sci. 27:352-367. 1930.

"...An attempt is made to outline the more important, more easily discernible changes in the vegetation following firing, in (1) climax grassland, (2) tree-and-grass savanna developing to either deciduous or evergreen scrub climaxes, (3) macchia or "fÿnbosch", (4) sub-tropical evergreen forest..." - from author's summary in Biol. Abs. 5(11): 2643. Nov. 1931. French summary, signed B. L., appears also in R. Gén. Sci. Pures et Ap. 42(10): 293-294. May 31, 1931.

164. RICE, L. A. The effect of fire on the prairie animal communities. "Literature cited": p. 400-401. Ecology 13(4): 392-401. Oct. 1932.

"Burning a plot of prairie near Seymore, Illinois, March 10, 1928, and March 8, 1929, showed the following effects upon the animal and plant life: The temperature was not great enough to kill all hibernating animals and they moved to nearby areas; the earthworm population was decreased due to burning of the surface vegetation; the new vegetation upon the burned area appeared earlier, grew more rapidly for a time, and seedlings of herbs replaced grasses on barren areas. Repeated burning produces a community in which herbs practically suppress grasses with probable corresponding changes in animals." - Author's summary, in Biol. Abs. 7(7): 1528. Aug./Sept. 1933.

165. THOMAS, A. R. Effect of slash burning on soil and succeeding vegetation. [Correspondence]. Indian Forester 64: 362-364. June 1938.

Observations on the adverse effect of fire on germination and growth of hollock (Terminalia myriocarpa).

166. UITTIEN, H., [and] Geerling, L. C. Culttuurproeven met striukheide (Calluna vulgaris Salisb.) 25p. illus. Pub. as Korte. Mededeel. Rijksboschbouwproefstat. [Unnumbered series] Reprinted from Nederland. Boschbouw-Tijdschr. Dec. 1932.

In Dutch, with English summary. Includes the effect of fire on succession. Old sods of heather and young birches were entirely destroyed, but most of the other species soon reappeared. Raphanus raphanistrum, which had not appeared in several years, suddenly germinated in numbers.

167. WOODWARD, John. Origin of prairies in Illinois. Bot. Gazette 77(3): 241-259. May 1924.

Includes a short discussion on the rôle fire has played in making the prairies treeless. The author holds that fire may have checked the invasion of forests into prairies, but prairies did not originate through destruction of forests by fire.

EFFECT ON SOIL

(See also entries 84, 85, 120, 160, 226, 231, 242, 243, 247, 248, 250, 256-258, 274, 275, 287, 290, 302, 313, 424, 430, 449, 499

168. ALWAY, F. J. Effect of burning the forest floor upon the productivity of jack pine land. Proc. Inter. Cong. Soil Sci. 3: 514-524. 1927. (1928)

"In a grove of Pinus banksiana in northern Minnesota in which there had been no fires and where the forest floor carried 6 tons of organic matter and 170 pounds of nitrogen per acre, 3 half-acre blocks were laid out, the trees felled in January and the stumps blasted and removed 4 months later. On one block all of the forest floor, as well as the slash, was burned and the ashes spread evenly before plowing. On the 2nd all burning was avoided, the slash and stumps removed and all of the forest floor plowed under; on part of this block an extra coating of forest floor was applied before plowing. On the 3rd block the slash was burned in piles, much of the forest floor being incidentally consumed as in the usual farm practice in clearing. After plowing the land was at once planted to corn, potatoes, barley and sweet clover. The yields of all the crops were practically alike on the 3 blocks, including the portion of the 2nd that received the extra coating of forest floor. It is concluded that the forest floor, when plowed under, exerts no depressing effect upon crop yields and that there is no advantage to be gained from its burning that will compensate for the large amount of nitrogen thereby lost."- Author's abstract, in Biol. Abs. 4(5): 1509. May 1930.

169. ALWAY, F. J., and Rost, C. O. Effect of forest fires upon composition and productivity of the soil. Proc. Inter. Cong. Soil Sci. 3: 546-576. 1927. (1928)

Contains good bibliography. "Immediately following an exceptionally disastrous forest fire in Minnesota in 1918, the surface of the burned over areas was carefully examined. Samples of forest floor, leafmold and the surface 6 inches of mineral soil were collected from uninjured forest, fire-killed woods and burned stump pastures. In the case of the most heavily burned portions of the forest the loss per acre of organic matter varied from 7-26 tons and of N from 450-1500 lbs., the losses of both being confined to the surface layer of organic residues. Even where the leafmold had been entirely burned off no evidence was found of loss of N in the uppermost portion of the mineral soil, or of any alteration in this except in some places a slight reduction in acidity, attributed

to the action of the lime in the ash. On the parts of the burned stump pastures where the leafmold was burned off, the losses per unit area were similar to the preceding, but as the burned spots were discontinuous and small the losses per acre were much smaller. The effect on the underlying mineral soil was similar to that in the burned forest. In vegetation experiments with soils poor in N the yields of barley, oats, sorghum and red clover were increased by the use of the leafmolds from a spruce-balsam-birch forest and from an oak grove applied at rates of 27-110 tons per acre. The beneficial effect of the leafmolds was lowered by burning and not increased by grinding. The authors conclude that the loss in productivity in mineral soils traversed by forest fires is dependent upon the completeness of destruction of the forest floor and the consequent loss of N, and not upon changes in the underlying mineral soil" - F. J. Alway, in Biol. Abs. 4(5): 1509. May 1930.

170. ALWAY, F. J., and McMiller, P. R. The floor of some northern Minnesota forests. tables. Amer. Soil Surv. Assoc. Bul. 14: 11-13. 1933.

Tables show percentage distribution of 239 samples of forest floor according to content of organic matter, nitrogen in organic matter and pH value, and of 109 samples according to lime content computing the loss in plant nutrients that may be caused by the complete burning of the forest floor, such as takes place in the severest forest fires, we are limited to the nitrogen, which, at 7 1/2 cents a pound the possible loss would vary from $7.00 to $86.00 per acre. "But with the growing of legumes to the extent that is advisable on land where none of the forest floor has been burned, it is an open question whether the succeeding crop yields will be any lower as the result of the destruction of the floor by burning. A seven-year experiment on deep well drained sand near Bemidji indicates that the loss under such circumstances is negligible." - from last paragraph, p. 13.

171. AUTEN, J. T. The effect of forest burning and pasturing in the Ozarks on the water absorption of forest soils. Columbus, Ohio, Nov. 20, 1934. 5p. chart. mimeo. (U. S. Forest Serv. Central States Forest Expt. Sta. Note 16)

Experiments conducted on sandy soil of Illinois and Arkansas show that in the case of Illinois silt loam soils there was a great decrease in water absorption capacity of severely burned forest and pastured soils compared with undisturbed woods soils. In the case of undisturbed woods the rate of water absorbed, liter by liter, remained fairly constant, but in the case of

burned woods and pastured soils the rate of absorption diminished with each application of water. For these soils (burned and grazed) the rate of absorption of the fourth liter was only 35 per cent that of the undisturbed forest soil.

172. BARNETTE, R. M., and Hester, J. B. Effect of burning upon the accumulation of organic matter in forest soils. Soil Sci. 29(4): 281-284. April 1930. Abstracted in Biol. Abs. 6(2): 526. Feb. 1932.

From comparisons of soil samples from Florida cut-over forest soil unburned for 42 years and similar soil which has been burned annually for 42 years it appears that protection conserves the organic matter and nitrogen. On the burned soils the loss of organic matter is 2,888 pounds per acre per year; the loss of nitrogen is 27 pounds per acre per year. "The importance of the pine as a means of increasing the organic matter supply and the ultimate fertility of these deep phases of the Norfolk sands cannot be overemphasized, and the effects of burning over these lands distinctly interferes with the accumulation of organic matter in the soil." - from last paragraph.

173. CHARLTON, J. A note on the effects of taungya on Burma forest soils. Agr. and Live-stock India. 6(1): 54-59. Jan. 1936.

Taungya, or forest burn-off experiments, were carried on in two reserves. "...It appears very likely that in the case of taungya carried out in an area carrying bamboo only the burning-off causes little in the way of chemical changes in the soil and hence in such areas has little effect beyond acting as a substitute for cultivation. On the other hand taungya carried out on areas covered by species other than bamboo or grasses has a profound effect on the lime requirements of the surface soils." - from p. 59.

174. CHEVALIER, Auguste. Sur la dégradation des sols tropicaux causée par les feux de brousse et sur les formations végétales régressives qui en sont la conséquence (Degradation of tropical soils caused by brush fires and the regressive plant formations that result). Compt. Rend. Acad. Sci. [Paris] 188(1): 84-86. 1929.

Noted in Biol. Abs. 4(6): 1840. June 1930.

175. CORSON, C. W., Allison, J. H., and Cheyney, E. G. Factors controlling forest types on the Cloquet forest, Minnesota. figs. Ecology 10(1): 112-125. Jan. 1929.

The effects of fire as an interfering factor in

classifying soils of this forest into their adaptability to the existing jack, Norway and white pine forest types.

176. ELVEDEN, Viscount. A contribution to the investigation into the results of partial sterilization of the soil by heat. tables. Jour. Agr. Sci. 11(2): 197-210. Apr. 1921.
Experiments with soils heated by steaming, with dry heat by flame and by electricity to various depths and up to 100°C, and the results on plants grown in such soils. Heating peat soil at 100°C, for 15 minutes greatly stimulated biological activity, as judged by CO_2 evolution.

177. ENEROTH, Olof. Bidrag till kännedomen om hyggesbränningens inverkan på marken. (Contribution to the knowledge of the influence of burning on the soil of clear-cut areas). illus. Svenska Skogsv. Tidskr. 26(3/4): 685-758. 1928. Reviewed by T. Blidberg in Jour. Forestry. 29(3): 412. March 1931. Translated by C. Mygind. (U. S. Forest Serv. Div. of Silvics Translation no. 61)
"Broadcast burned clearings on better soils were studied. It is known that burning improves raw humus types but opinions are not agreed in the case of more productive sites. Soil samples were taken on a large number of cuttings at various periods after burning, and analyses were compared with unburned plots on the same areas. Acidity was determined colorimetrically. Humus on clearings was not consumed by fire, provided burning did not occur in mid-summer. Burned clearings showed throughout a higher pH value than unburned. The chemical composition of the ash changed rapidly following the fire, especially if rains occurred. Burning brought about soil conditions similar to those on more productive sites, and seemed to make more favorable conditions for conifer growth." - H. I. Baldwin, in Biol. Abs. 5(1): 203. Jan. 1931.

178. FERNOW, B. E. Economics of forestry. N. Y., Thomas Y. Crowell and co., [c1902]. 520p.
Loss of soil cover, litter and duff, by fire, p. 189; other disturbing effects of fire in forests, p. 366-368.

179. FERNOW, B. E. The management of burned forests. Proc. Amer. Forestry Cong. 2: 38-42. 1883.
The author shows the deteriorating effects of fire upon forest soil and standing timber. Quotes from C. C. Sargent in the case of a burned white pine forest.

180. FLETCHER, F. Effect of previous heating of the soil on the growth of plants and the germination of seeds. illus., tables. Cairo Sci. Jour. 4(43): 81-86. Apr. 1910.
Plants made better growth on soils previously heated

to 95 and 170 C. than upon unheated soils. The author does not believe that the advantage of heating comes from changing the bacterial flora or increasing the soluble matter, but that it destroys some toxin present in unheated soils.

181. FLINT, H. R. Fire as a factor in the management of north Idaho national forests. Northwest Sci. 4(1): 12-15. Mar. 1930.

In the recent past fire has often been the agent which has brought widespread change in these forests, including (1) the change of surface soil from acid to alkaline (2) increased light intensity at the ground (3) widened range of temperature (4) increased rate of evaporation and (5) reduction and sometimes complete elimination of many soil organisms from the habitat.

182. FOSTER, J. H. Grass and woodland fires in Texas. College Station, 1916. 16p. (Texas Agr. and Mech. Coll. Dept. Forestry. Bul. 1)

Frequent burning is one of the most serious and deceptive problems of east and central Texas. This bulletin cites their damage, with special emphasis on destruction of the humus.

183. FOWELLS, H. A., and Stephenson, R. E. Effect of burning on forest soils. "References": p. 181. Soil Sci. 38(3): 175-181. 1934.

A study made in western Oregon on four Olympic clay soils to a depth of 6 inches. Conclusions are that burning may be of temporary benefit to soils in some respects and produces a liberal supply of plant food, but continued burning impoverishes the soil because productivity of forest soil depends upon gradual mineralization of the litter.

184. GREENE, S. W. Effect of annual grass fires on organic matter and other constituents of virgin longleaf pine soils. "Literature cited": p. 821-822. Jour. Agr. Research 50(10): 809-822. May 15, 1935.

In 1923, about 20 years after virgin timber had been removed, 320 acres of virgin land in Mississippi were divided into 4 experimental areas. 2 acres were grazed, one of which was winter burned annually. Two 10-acre areas were not grazed, one of which was burned annually. After 8 years the results include: There was 1.6 times more organic matter and 1.5 more nitrogen in the burned-over land than in the unburned, which was reflected in increased number of soil micro-organisms. Quantity of grass and legume growth on ungrazed burns was more than double that of the unburned areas. Annual burning

returned the non-volatile fertilizing elements to the soil immediately. The accumulation of plant debris on top of the soil did not materially increase soil moisture in spite of the fact that much greater amounts of water were required to support the extra forage growth on the burned-over soils.

185. HEIKINHEIMO, Olli. Metsänhävityksen ja polton vaikutuksesta metsämaahan (The influence of forest devastation and burning on forest soil). tables. Acta Forestalia Fennica 8: 1-28. 1918.

Destruction of microflora and microfauna and chemical and physical changes in the humus. Includes soil and water relationships after burning.

186. HEYWARD, Frank, and Barnette, R. M. Effect of frequent fires on chemical composition of forest soils in the longleaf pine region. Gainesville, Fla., 1934. 39p. illus. "Literature cited": p. 39. (Fla. Agr. Expt. Sta. Bul. 265) Summary appears in Southern forestry note 7, 1934, p. [4]. Summary appears also in Naval Stores Rev. 44(21): 13. Aug. 25, 1934.

Tests for total nitrogen, loss on ignition, replaceable calcium, and acidity on soils subjected to annual fires, and on comparable adjacent soils protected from fires indicated that the former contained less acid, and had higher percentages of replaceable calcium and total nitrogen, and these burned soils were characterized by larger quantities of organic matter. Changes in chemical composition of the soils ascribable to fire were restricted to the top 4 to 6 inches.

187. HEYWARD, Frank. Effect of frequent fires on profile development of longleaf pine forest soils. illus. Jour. Forestry 35(1): 23-27. Jan. 1937.

When annual fires remove the ground cover from longleaf pine forest soils the A_1 horizon is dense, relatively impenetrable, due to the absence of vigorous soil fauna. No forest floor is present; thrifty perennial grasses form the ground cover and the soil is morphologically more similar to grassland than forest soils.

188. HEYWARD, Frank, Barnette, R. M., and Tissott, A. N. Field characteristics and partial chemical analysis of the humus layer of longleaf pine forest soils. Gainesville, Fla., 1936. 27p. illus. "Literature cited": p. 25-27. (Fla. Agr. Expt. Sta. Bul. 302)

Where longleaf pine forests are subjected to recurrent fires, the forest stand itself exerts little or no influence on the humus type, which assumes a humus layer typical of grassland, and is essentially a "fire climax."

It requires from 8 to 12 years of protection from fire to develop a forest floor of from 20,000 to 55,000 pounds per acre. Annual needlefall in second-growth stands of slash and longleaf pine is from 2,400 to 3,500 pounds per acre.

189. HEYWARD, Frank. Soil changes associated with forest fires in the longleaf pine region of the South. Amer. Soil. Surv. Assoc. Bul. 17: 41-42. 1936.

"Studies to date reveal that soils protected from fire are much more penetrable and porous than soils subjected to fire... Soils subjected to frequent fires show a slightly higher ignition loss, due probably to charcoal. They contain more replaceable calcium and probably other ash constituents, and are, therefore, slightly less acid. They likewise contain a higher percentage of total nitrogen. No evidence is at hand indicating severe soil degradation due to periodic fire, nor is there any indication that the forest soils of the longleaf pine region are definitely benefited by fire. That frequent fires do not materially destroy organic matter below the top one-fourth inch of mineral soil may be attributed to the fact that beneath this depth the soil is rarely heated to the ignition point of organic matter." - from summary, p. 42.

190. HEYWARD, Frank. Soil temperatures during forest fires in the longleaf pine region. illus. "Literature cited": p. 491. Jour. Forestry 36(5): 478-491. May 1938.

Results from data recorded after 44 experimental fires indicate that heat from the majority of fires in this area is unsufficient to impoverish the soil, and that the slight heat which does enter the soil may favor plant nutrition. This is a comprehensive paper on direct effect of heat on soil, with a summary of previous literature on the subject.

191. HEYWARD, Frank, and Tissot, A. N. Some changes in the soil fauna associated with forest fires in the longleaf pine region. Ecology 17(4): 659-666. Oct. 1936.

The Ao horizon of soils under dense long-unburned longleaf pine forests is an excellent habitat for a diversified soil fauna, and contains approximately 5 times as many microfaunal forms as the ground cover of frequently burned similar soils. This diversified active soil fauna is believed to be responsible for the penetrable and well-aerated soil typical of such unburned areas, in contrast to the compact, less porous soil of burned areas, in which animal activity is much less abundant.

192. HURSH, C. R. Litter keeps forest soil productive. illus. South. Lumberman. 133(1734): 219-221. Dec. 22, 1928.
Annual return of hardwood leaf litter and its values if purchased, and the effect of fire on soil, not only in depriving it of fertilizer but its consequent erosion and leaching.

193. JACQUOT, André Incendies en forêt; dommage causé par la disparition de la couverture (Forest fires; damage through loss of the soil covering). tables. Rev. Eaux et Forêts. 41(11): 340-346. June 1, 1902.
Summary of early experiments showing soil values which are destroyed by one fire and repeated fires. Translation of part of the article and comments by F. Gleadow appear in Indian Forester 29(3): 93-98. March 1903.

194. LOVEJOY, P. S. Effect of forest fires upon the soil of the north Lake states. "List of references": p. 20. Mich. Acad. Sci. Rept. 22: 9-20. 1920.
The author points out that there is insufficient reliable and applicable data to support either theory that forest fires are detrimental or beneficial to soil in the Great Lakes region. Dr. Marbut of the U. S. Soil Survey, on the basis of limited studies and on studies of German specialists states that the accumulation of forest debris is injurious not only to the soil but to the forest as well, and anything that will remove it is beneficial. On the other side of the argument Snyder records a loss from the soil of 2,500 pounds of nitrogen per acre as a result of the Hinckley, Minnesota fire. Mosier estimates a loss of 1,600 pounds of nitrogen per acre valued at $480, as a result of forest fires in the Lake States region. Another factor to be taken into consideration is soil erosion following forest fires. Includes quotations from these and other authorities for and against burning. The author concludes that it is an outrage to advocate the destruction of the organic material of forest soils by fire.

195. LYON, T. L., and Bizzell, J. A. Effect of steamsterilization on the water-soluble matter in soils. Ithaca, N. Y., 1910. [26]p. illus. (Cornell Univ. Agr. Expt. Sta. Bul. 275)
This bulletin is of interest to this bibliography primarily because of its review of previous experiments on application of moist and dry heat to soils.

196. MARSHALL, Robert, and Averill, Clarence. Soil alkalinity on recent burns. Ecology 9(4): 533. Oct. 1928.
One year after severe fire on the Kanisku national forest in Idaho, the hydrogen ion concentration of the

soil was determined at 60 localities throughout the burn, using a La Motte Indicator field set. 58 of the localities showed pH values between 7.0 and 8.0. In the two localities showing acid reactions the duff and humus had been merely scorched. Authors suggest that this alkalinity may contribute to scarcity of reproduction in western white pine until the lye manufactured by the fire has been leached from the soil.

197. MATTOON, W. R. Forest fires and fertilizer. Service Bul. (U. S. Forest Serv.) 10(4): 4-5. Jan. 25, 1926.
The author estimates the loss of $4.00 an acre in fertilizer alone after a ground fire in oak timber. This does not take into account indirect damage in compacting the soil and increasing run-off and erosion.

198. NICHOLLS, H. A. A. The harmfulness of bush fires in the West Indies. Indian Forester 27(7): 384-390. July 1901. Appears also as Pam. 4 of the Imp. Dept. Agr. West Indies, 1901.
Five classes of bush fires in the West Indies and their harmful effects tabulated: 1. They destroy nitrogenous matter that would have fertilized the soil. 2. They destroy nitrogenous matter already in the upper layers of the soil. 3. They destroy the nitrifying microfauna of the upper layers of the soil, and for a time prevent the fixation of nitrogen for the use of vegetation.

199. PERRY, G. S. Some chemical and physical effects of forest fires on soil. Proc. Penn. Acad. Sci. 5: 123-127. 1931.
In testing burned and unburned forest soils it was concluded that forest fires temporarily decrease the acidity of soils. Fire does not make the soil finer. Most organic matter loss is not actually caused at the instant of the fire, but results later. Burning decreased the percolation property of the soil.

200. PERRY, G. S., and Coover, C. A. Some effects of fire on forest soils of Snowy mountain, Mont Alto state forest, Pennsylvania. Proc. Penn. Acad. Sci. 7: 43-49. 1933.
A study of unburned and burned-over forest soils indicates: (1) Forest fires permit percolating water to deposit the most valuable fraction of the soil in the subsoil, where roots of most trees derive little benefit therefrom. (2) Forest fires are a primary contributing cause of soil degeneration, podsolization. (3) Fires destroy the normal and fairly uniform gradation of organic content. (4) Fires reduce somewhat the organic content of the soil. (5) Forest stands investigated showed a reduction of 60 to 70 per cent in volume growth of trees on frequently burned sites as contrasted

with those on protected sites, despite wider crowns and more growing space on the burned sites.

201. PETERSON, C. I. Does it pay to burn the range? Nashville, Tenn., 1927. 10p. (Tenn. Div. Forestry. Circ. 11)
A warning to farmers and stockmen against woods burning in the South. "...A ton of oak leaves contains fertilizing ingredients that would cost the farmer $2.90 if bought on the market; a good stand of mature oak trees will produce about 2 tons of leaves per acre per year." - from p. 5.

202. PICKERING, S. U. The action of heat and antiseptics on soils. tables. Jour. Agr. Sci. 3(1): 32-54. Dec. 1908.
The effect of heat and antiseptics had the same effect--soluble organic matter is increased, exhibiting an inhibitory effect on germination of seeds and increasing growth of plants grown in them.

203. PICKERING, S. U. Plant-growth in heated soils. illus., plates. Jour. Agr. Sci. 3(3): 277-284. Sept. 1910.
A review of previous experiments of this author and others, and results of further studies on effect of heating of soil upon plant growth showing that the soluble matter available for nutrition is increased. The author notes the changes in the bacterial condition which are conducive to increased vigor of plants.

204. PICKERING, S. U. Root action and bacteria. Nature 76(1962): 126-127. June 6, 1907.
A study of 26 trees planted in pots, 17 in unheated soils and 9 in soil heated to 200°C. and to 82°C. Growth in the heated soil was retarded. Heating soil to 82° could not have affected its chemical composition, and does not destroy all soil bacteria. Therefore the heat must kill some particular bacteria which are connected with root activity.

205. PICKERING, S. U. Studies of the changes occurring in heated soils. tables, plates. Jour. Agr. Sci. 3(3): 258-276. Sept. 1910.
Describes in detail methods of experiments, analysis and results of a series of experiments to determine the presence of a toxic substance in heated soil which retards germination.

206. PICKERING, S. U. Studies in germination and plant-growth. Jour. Agr. Sci. 2(4): 411-434. July 1908.
Soils which have been heated without drying to temperatures from 60° to 150°C, are unfavorable toward seed germination and toward starting growth in the tree.

Heating appears to be due to the formation of non-acid nitrogenous compound in the soil. The greatest quantity of this inhibitory substance is found when temperature of 200°C. is reached. It diminishes in amount as the temperature is further raised and disappears entirely at a low red heat, such burnt soil behaving in nearly the same way toward germination as does unheated soil.

207. QUISUMBING, Francisco, and Ocfemia, Gerardo. Some chemical and bacteriological effects of clearing grass land by burning. Philippine Agr. and Forester 3(4): 76-78. 1914.

A summary of the authors' work at the Philippine College of Agriculture noting loss of one third of the nitrogen and humus to the depth of 10 centimeters (destruction is probably limited to the top third of the depth) and reduction of bacteria count. On the other hand, benefits which may accrue are making mineral plant-food more immediately available, destruction of the protozoal enemies of the soil bacteria, destruction of the insect pests and eradication of weeds. Whether the net result is beneficial or destructive depends upon the soil type, the climate and character of the crop to be grown.

208. RICHARDSON, H. W. The northeastern Minnesota forest fires of October 12, 1918. Geographical Rev. 7(4): 220-232. April 1919.

Contains a section "Effect of the fire on the soil." The general opinion among practical men is that this fire did little or no damage to the soil. Settlers generally believed that burning is beneficial to peat soils. Author maintains that a forester stated that if fires are allowed to burn in the peat lands down to the white sands it will be but a matter of time until Minnesota will have a moving sand-dune problem like Nebraska's.

209. RUSSELL, E. J., and Hutchinson, H. B. The effect of partial sterilization of soil on the production of plant food. illus., plates. Jour. Agr. Sci. 3(2): 111-144. Oct. 1909.

At Rothamsted Station soils were heated to 98°C. and treated with volatile antiseptics. Fertility of the soil was heightened, due to an increase in the nitrogenous food made available as a result of quickened activity to certain nitrifying bacteria not present in unheated soils. Heat and antiseptics killed the protozoa and most of the bacteria, but the latter soon take a new lease on life from the unharmed spores, and finding themselves unattacked by their enemies, reproduce in great numbers, thus causing increase of the soluble nitrogenous matter.

210. RUSSELL, E. J., and Petherbridge, F. R. On the growth of plants in partially sterilized soils. illus., plates. Jour. Agr. Sci. 5(3): 248-287. June 1913.
Includes the effect of heating soils from 55°C. to 100°C.

211. SCHEFFER, T. C. Sterilization of coniferous seed-beds with low pressure steam. "References": 49. Jour. Forestry 28(1): 42-49. Jan. 1930.
Description of experiments and results on the effectiveness of steam sterilization in (1) preventing damping-off of seedling conifers, (2) reducing weed problem, (3) effect in development of seedlings and (4) various secondary factors in the soil.

212. SCHREINER, Oswald, and Lathrop, E. C. The chemistry of steam-heated soils. Wash., Govt. print. off., 1912. 37p. (U. S. Bur. Soils. Bul. 89)
Includes beneficial and harmful effects of heating the soil in the laboratory. Some of the conclusions may be applied to the accidental heating of forest soil by fire.

213. SEAVER, F. J., and Clark, E. D. Biochemical studies on soils subjected to dry heat. illus. Biochem. Bul. 1(3): 413-427. March 1912.
Growth of green plants used in this study was slightly accelerated in soils heated to 90-120°C. but above this point, growth is retarded, the retardation increasing with the temperature. The influence of heating soils on the fungi is the opposite of that on the growth of green plants. The preference of certain plants for burned-out areas may be explained by the acidity of such situations. A review of the literature of the subject to 1911 is included.

214. SEAVER, F. J., and Clark, E. D. Studies in pyrophilous fungi. II. Changes brought about by the heating of soils and their relation to the growth of pyromena and other fungi. illus. Mycologia 2(3): 109-124. May 1910.
Heating soil to a high temperature brings about chemical changes indicated by (1) the extract of heated soil is amber or reddish brown and possesses a characteristic odor, while the extract of unheated soil is colorless and almost odorless; (2) the amount of soluble material in the heated-soil extract is increased to approximately 6 to 10 times the extract of the unheated soil. This increased amount of soluble material serves as plant food and encourages the growth of the fungus.

215. SEN GUPTA, B. Fire conservancy in Indian forests. illus. Indian Forester 36(3): 132-145. March 1910.
Covers effect of fire on the soil and on forest types. See entry 220 for reply by H. S. Walker on the effects of fire on soil chemistry.

216. STONE, G. E. The present status of soil sterilization. In Mass. Agr. Expt. Sta. Ann. Rept., 24th. 1912. p. 121-125.
Includes observations on the luxuriant plant growth on site of abandoned charcoal pits.

217. SUSHKINA, N. N. Nitrifikatsia v lessnykh pochvakh v z avissimosti ot sostava nasjdenia, rubki i ognevoi ochistka lessosik (Nitrification of forest soils with reference to the composition of the stands, cutting and fire). Izvestia Akademii Naouk S.S.S.R. 1933, p. 111-159.
Work done at the Leningrad Research Institute of Forest Industry, under the direction of M. E. Tkachenko. Includes a review of literature on chemistry of forest soils and effect of certain factors upon it. Paper deals with clearing of land by different methods, of which burning is included. Among the conclusions reached are: Fire always has a stimulating effect upon nitrifying processes in forest soils. Moderate burning has a more favorable effect than intense burning. In certain cases the beneficial effect of burning was evident within two days, and lasted for five years. A running fire has a more favorable effect upon nitrification than burning debris in piles. U. S. Forest Service Library has type-written translation of the paper, by C. P. de Blumenthal.

218. TOPHAM, Paul. Forest fires in relation to soil fertility. Nature 132(3324): 102. July 15, 1933.
Short article following up paper by F. P. Worley on effect of fire on soils (See entry 224). The author discusses the use of fire to obtain soil fertility in Nyasaland, where timber is stacked 3 feet deep and burned, causing a very intense heating of the soil. A somewhat different method is used on golf courses to keep them green.

219. VATER, H. Verhalten des Fichtenauflagehumus bei der Erwärmung in Bezug auf die Erhaltung der Keimkraft (Behavior of surface humus of spruce stands after heating due to forest fires, with regard to the preservation of the germinative capacity). Tharandt. Forstl. Jahrb. 80(3): 65-69. 1929.
The author refers to Münch's and Neubauer's experiments showing that the surface humus of spruce stands, when heated to higher temperature than occurs in nature, loses to a certain degree the capacity of yielding nutrients to higher plants.

220. WALKER, H. S. Fire conservancy in Indian forests. Indian Forester 36(7/8): 356-360. June/July 1910; 36(11/12): 679-686. Nov./Dec. 1910.

A reply to R. Sen Gupta (See entry 215) on the effect of fire on the theory of toxic excretions. The author believes that the soil is benefited by heating and the exposure and consequent aeration after burning. In his second article the author doubts if fire protection materially decreases erosion and floods in this area.

221. WILLIAMSON, B. F. Fires that burn deep. chart. Amer. Forestry 36(2): 92. Feb. 1930.

Core borings of soils under virgin pine in Florida to a depth of 45 inches on two areas, one burned annually for 42 years, the other unburned for the same length of time. Chart shows loss of organic matter and nitrogen at various depths on burned area.

222. WILSON, A. Changes in soils brought about by heating. tables. "References": p. 520. Scien. Proc. Roy. Dublin Soc. 14(38): 513-520. May 1915.

"The results of these experiments show that at any rate part of the increased productivity of heated soil may be due to the increase in soluble matter induced by heating, and to the change in soil-texture, which has a remarkable effect on the retention of water by the soil." - from summary, p. 519. Soil samples were taken from a depth of not more than 6 inches from the surface and heated to between 60° and 150°.

223. WILSON, G. W. Studies of plant growth in heated soil. Biochem. Bul. 3(10): 202-209. Jan. 1914.

Results of a series of experiments which indicated that (1) delayed germination, (2) retarded growth and (3) increased susceptibility to disease characterized all crops grown in soil heated to 175°C. Heating soils to low temperature of 95°C., however, accelerated growth and vigor of plants.

224. WORLEY, F. P. Forest fires in relation to soil fertility. Nature (London.) 131(3318): 787-788. June 3, 1933. Discussion by P. Topham in Nature (London.) 132(3324): 102. July 15, 1933. Résumé in Rev. Gen. Sci. 45: 130-131. Mar. 15, 1934.

A professor at Auckland university, New Zealand, shows that although burning is the only practicable method of bringing bush land into cultivation, too little consideration has been given to burning methods, and this has resulted in lowered soil fertility. Seeds and leaves of karaka and perhaps other native trees contain copper which is returned to the soil. Copper is present

normally in minute amounts in the soil but, like manganese, is gradually brought to the surface by tree growth. Thus, forests bring to the surface various chemical elements extracted from the deeper soil, and build up humus layer on the surface. Burning allows this to leach and wash away; thus the work of the forest not only has been in vain but even has been detrimental, in that the soil to the depths of the tree roots has been impoverished in minor mineral constituents necessary to plant growth.

EFFECT ON RANGES AND PASTURES

(See also entries 6-8, 17, 115, 116, 161, 162, 164, 168, 184, 187, 202-207.)

225. AINSLIE, J. R. Forestry and tsetse control in Northern Nigeria. Empire Forest. Jour. 13(1): 39-44. 1934.

"It has been assumed in the past that tsetse control and forest preservation were to a large extent mutually irreconcilable because late burning was destructive to the woods and also to birds which eat the fly. Early firing, however, catches a large proportion of the flies in the grass and low shrubs and causes seeds dormant in the soil to germinate and root suckers to grow. It also improves the grazing conditions for cattle which can withstand tsetse attack if properly nourished." - C. E. Skamser, in Biol. Abs. 9(5): 1117. May 1935.

226. ALDOUS, A. E. Effect of burning on Kansas bluestem pastures. [Topeka, Kans., 1934.] 65p. illus. (Kans. Agr. Expt. Sta. Tech. Bul. 38) Summary appears in Serv. Bul. (U. S. Forest Serv.) 19(17): 2-3. Aug. 19, 1935.

Experiments started in 1927 near Manhattan, Kans., to find the effect of burning on (1) yield of vegetation (2) control of weeds and brush (3) quality of vegetation (4) soil moisture and temperature (5) composition and succession of vegetation (6) starting growth in the spring (7) fertility of the soil. Some of the results were: (1) Burning decreased yield of mature vegetation; yield was least on plots burned late in the fall. (2) Burning had little effect in controlling weeds and brush. (3) Moisture content of soil was higher on unburned than on burned plots. (4) Burning stimulated early growth in the spring. (5) Burning did not cause a decrease in the organic matter or total nitrogen during a 5-year period. The accumulation of organic matter and total nitrogen in prairie grassland is governed

more by root development than by surface accumulation. Burning was done while soil was moist; otherwise the results may have been different, the author concludes.

227. ALDOUS, A. E. The eradication of brush and weeds from pasture lands. illus. Jour. Amer. Soc. Agron. 21(6): 660-665. June 1929.

"Three methods of eradication were used: chemicals or herbicides, burning, and cutting above ground... Burning late in the spring was effective in killing both weeds and brush..." - from author's abstract in Biol. Abs. 5(1): 190. Jan. 1931.

228. BARNES, W. C. The care of the range. In his Western grazing grounds and forest ranges. Chicago, The Breeder's Gazette, 1913, p. 226-245.

This chapter includes a section "Burning off a range", which warns that burning destroys the best grasses and perpetuates the worthless weeds and plants.

229. BENNION, Glynn. More about burning sagebrush. Natl. Wool Grower 14(11): 34. Nov. 1924.

Describing a flourishing Utah range in 1860 and its depleted condition in 1924, due to overgrazing and burning. The author believes that careful burning does not cause floods.

230. BENNION, Glynn. Re-grassing the range. illus. Natl. Wool Grower 14(6): 19-21. June 1924.

Includes a section about a rancher who burned a part of his sagebrush range to bring it back to its original grass condition, which is accomplished by burning the sage during seasons of drought and protecting the area from grazing during the grazing season. The sage roots are killed, but most of the grass roots are uninjured. Freed thus from competition, in a few years the burned land goes back to sod of bluestem and bunch grass.

231. BURNS, W., Kulkarni, L. B., and Godbole, S. R. Further studies of Indian grasses and grasslands. illus. Mem. Dept. Agr. India. Bot. Ser. 16(4): 101-143. 1928.

"In continuation of a previous report, investigations from 1925 to 1928 on grasslands in the Bombay Presidency are recorded, including results of controlled grazing, seeding, planting grasses vegetatively, and control of erosion, especially the effect of these processes on the stand growth of desirable pasture grasses. Burning tended to permit deeper penetration of water, but on shallow soils was detrimental to both soil texture and plant population. On good soil with high water content, burning in February may be beneficial..." - from H. N. Winall, in Biol. Abs. 4(6): 1836. June 1930.

232. BUSH fire problem; editorial. Australian Forestry 2(2): 2. Dec. 1937.

The marginal and sub-marginal grazing land in parts of Australia must be burned at frequent intervals to provide a limited amount of stock feed which, at best, provides a poor living for a few stock owners. Most of the serious fires result from this burning. This editorial states that controlled burning at the proper season is more expensive than this class of land deserves, so, as a matter of economics, grazing and burning should be prohibited on these areas.

233. BUTTRICK, P. L. Grass burning in relation to forest fires in Connecticut. In Conn. State park and forest comm. Connecticut forest fire problems, 1926, p. 6-8.

A non-technical article, discouraging light burning by farmers. The author believes that, although burned pastures show green earlier in the spring than unburned areas, actually the new growth does not start any sooner.

234. CALIFORNIA state board of forestry. Biennial report, 1st, for the years 1885-1886. Sacramento, Supt. state print., 1886. 238p.

p. 200-201 contains a discussion as to why much of the grazing land in California is rapidly becoming converted into brush land, which condition is attributed to the cessation of Indian light burning. "...and to it (the Indian system) we undoubtedly owe the noble forests which were transmitted to our lands." - from p. 200.

235. CAMP, P. D. A study of range cattle management in Alachua county, Florida. Gainesville, Fla., 1932. 28p. illus. (Fla. Agr. Expt. Sta. Bul. 248)

"Effects of burning the range", p. 16-17, give prevalent opinions, but the author neither recommends nor condemns it until further evidence is found.

236. COMPTON, R. H. Veld burning and veld deterioration. South African Jour. Nat. Hist. 6(1): 5-19. 1926.

"An address calling attention to the serious biological and economic consequences of veld burning, and appealing for a clearly expressed general demand for control." Biol. Abs. 2(9/11): 1479. Sept./Nov. 1928.

237. EFFECTS of fire on grazing and the production of grass. Indian Forester 24(2): 55. Feb. 1898.

Note on supposed beneficial and harmful effects of burning of pastures, inviting further study of the problem.

238. FORSLING, C. L. Fire and the range improvement problem. Natl. Wool Grower 14(7): 13-14. July 1924.

Points out the danger of burning sagebrush range in order to revert it to productive grass land, from the angle of erosion and the harmful effect upon the remaining desirable grasses themselves. For comments on the article by Glynn Bennion, see entry 229.

239. GRABER, L. F. Injury from burning off old grass on established blue-grass pastures. Jour. Amer. Soc. Agron. 18(9): 815-819. Sept. 1926.

"Spring burning of accumulation of 2-years' ungrazed growth reduced subsequent yields 52.4 per cent if done while the soil was still frozen. When burned after thawing, the season's yield was 71.3 per cent less than on adjacent unburned areas. Heavy growths of summer weeds infested the burned-over bluegrass, but were entirely absent in the adjacent unburned plots. Rhizome and root growth in the surface soil of burned plots was 34 per cent less than in unburned areas, indicating injury to subterranean parts. Such injury not only thinned the grass, but weakened the growth by reducing root development, by lowering absorptive capacity and by reducing amount and availability of organic food reserves." - Author' abstract in Biol. Abs. 1(6): 918. Oct. 1927.

240. GREENE, S. W. Grazing as affected by range fires in the longleaf pine belt. Proc. South. Forestry Cong. 5: 47-54. 1923.

An address by the Superintendent of the Coastal Plain Experiment Station, McNeill, Miss. Burning lowers the carrying capacity of the range. It promotes oak thickets and perpetuates undesirable grasses and prohibits the desirable ones. Describes a projected 10-year experiment in cooperation with the U. S. Forest Service on the effects of fire and grazing in the Piney Woods.

241. GREENE, S. W. Range fires in the longleaf pine belt. Lumber World Rev. 42(4): 48. Feb. 25, 1922.

A paper read before the 4th annual session of the Southern Forestry Congress at Jackson, Miss., 1922, and a summary of a discussion by H. E. Hardtner. Annual burning in the piney woods deteriorates the soil and eliminates the more valuable grasses and palatable plants. The author predicts that if the practice is continued the piney woods will eventually become a grass country.

242. GREENE, S. W. Relation between winter grass fires and cattle grazing in the longleaf pine belt. Jour. Forestry 33(3): 338-341. March 1935.

At the Mississippi Agricultural Experiment Station

two pastures of 150 acres each were established, one pasture being burned annually in winter, the other protected. Both pastures were grazed equally, the only variable factor being the use of fire. After eleven years of experiments the author concludes that herds pastured on the burned areas were heavier, sleeker and, in general, in much better condition than those grazed on unburned areas.

Soil temperature was higher at depth of 3 inches on the unburned area which was a factor in producing earlier growth on burned areas. Native legume plants after 9 years of burning were more than twice as abundant on the burned area. Soil samples revealed more organic matter and nitrogen on the burned area.

243. GREENE, S. W. The stockman's interest in protecting forest and range from fire. illus. Proc. South Forestry Cong. 11: 52-59. 1929.

Cattle made 44.4 per cent greater gains on burned native grass pastures than on similar unburned areas over a period of 4 years. Balanced against this are these results: Impoverishment on the soil by destroying organic matter which should be left, and the removal of ash in the run-off from heavy winter rains. Sheet erosion following burning is evident on burned areas. Controlled grazing at the rate of one head to 10 acres increased pine seedling survival more than 300 per cent on areas subject to annual fires.

244. GRIFFITHS, David. Forage conditions on the northern border of the Great Basin. Wash., Govt. print. off., 1902. 60p. illus. (U. S. Bur. Plant Ind. Bul. 15)

Investigations made in 1901 in the region between Winnemucca, Nevada, and Ontario, Oregon. p. 31-33, with illustrations, cover the damage to the range by fires. Fire is as destructive to the grass on the range as in timber, and it takes both years to recover from a single fire, the author concludes.

245. HANSON, H. C. Improvement of sagebrush range in Colorado. Fort Collins, Colo., 1929. 12p. illus., tables. (Colo. Agr. Expt. Sta. Bul. 356) Abstracted by H. M. Steece (courtesy Expt. Sta. Rec.) in Biol. Abs. 5(10): 2420. Oct. 1931.

Burning the range in northern Colorado in October was more effective than grubbing in destroying the sagebrush, and natural seeding to grasses was not necessary to produce a stand of palatable grasses the first year following the burning, and the stand increased even more the second year. Observations made on areas that were burned 5 to 10 years ago indicate that the grass on these areas is still good, even when heavily grazed.

246. HART, G. H., Guilbert, H. R., and Goss, H. Seasonal changes in the chemical composition of range forage and their relation to nutrition of animals. "Literature cited": p. 61-62. Berkeley, Calif., Univ. of Calif., 1932. 62p. tables. (Calif. Agr. Expt. Sta. Bul. 543)

"Variations in chemical composition of forage from adjoining burned and unburned areas", p. 31-33. Forage from burned areas is more palatable to livestock during the first year following the fire. In one area there was an increase of phosphorus in broadleaf alfilaria and wild oats, but samples taken from more fertile areas did not substantiate this result.

247. HENSEL, R. L. Effect of burning on vegetation in Kansas pastures. Jour. Agr. Research 23: (8): 631-644. Feb. 24, 1923.

Experiments at Kansas Agricultural Experiment Station to obtain data on (1) effect of burning on temperature of the soil at 1- and 3-inch depths during the growing season (2) effect of burning upon grasses (3) on weeds (4) on the yield.

Results indicate that: (1) The evil effects of burning, if any, are not apparent in the first four years. Burning at the end of this time had not caused the number of grass plants to decrease. (2) Sedges decreased on the burned areas, and increased on the unburned. (3) When the experiment was begun (1918) both experimental areas were practically free of weeds. The next year a great many were found on both, but from 1919 on there was a decrease in weeds on the burned area, and an increase on the unburned area. (4) Mean maximum soil temperatures at 1- and 3-inch depths were higher on the burned area. (5) Yield results were not conclusive, either way. Conclusion of studies carried on so far do not show that burning is injurious, but more and varied experiments are necessary before final conclusions regarding burning can be arrived at.

248. HENSEL, R. L. Recent studies on the effect of burning on grassland vegetation. Ecology 4(2): 183-188. Apr. 1, 1923.

A less technical description of the experiment and results of preceding entry.

249. LEVYNS, M. R. Veld-burning experiments at Ida's Valley, Stellenbosch. illus. Trans. Roy. Soc. South Africa. 17(2): 61-92. 1929.

"Five experimental plots separated by fire paths were established on rhenosterveld in 1924; 3 were burned at the end of the summer, 1 was cleared, and the remaining plot left as a control. Results show that

rhenosterveld is not a stable type of plant community, being merely a protracted stage in succession. Burning leads to rapid increase of the rhenoster bush (Elytropappus rhinocerotis) and certain other plants. Burning induces a temporary vigorous growth among the petaloid monocotyledons and a few other plants..." -- From author's abstract in Biol. Abs. 4(6): 1646. June 1930.

250. LIEBENBERG, L. C. C. Veld burning. [pt. 1] How it affects the farmer as well as the country. [pt. 2.] Its influence on various types of vegetation. illus. Farm. So. Africa 9(99): 213-215. June 1934; 9(100): 265-266, 278. July 1934.

Two articles pointing out the far-reaching effects of burning on vegetation, as well as soil deterioration with its attendant erosion and dessication. Experiments may in the future bring to light beneficial results of light burning, but studies up to the present seem to show that it is a harmful practice.

251. MARCKWORTH, G. D. How forest fires damage the cattlemen. Nashville, Tenn., 1922. 7p. (Tenn. Forest Bur. Circ. 2)

Deterioration of the range due to repeated light burning.

252. MUNDY, H. G. The grass fire evil. Rhodesia Agr. Jour. 35(2): 98-99. Feb. 1938.

Eight damaging effects of indiscriminate veld burning in Southern Rhodesia, including soil deterioration, causing accelerated erosion, loss of wildlife and timber, destruction of nutritious grasses and increase of hardier but less desirable ones.

253. PHILLIPS, E. P. A preliminary report on the veld-burning experiments at Groenkloof, Pretoria. illus. South Africa. Jour. Sci. 16(4): 285-299. Jan.-March 1920.

In studying 5 experimental burned plots, these tentative results were obtained: (1) Certain dominant grasses were replaced by invading species after several years of burning of the soil. (2) A covering of vegetation keeps the soil at a more even temperature than soil denuded by burning. (3) Denuded soil absorbs more water after rain than similar covered soil, but the soil covered by vegetation loses its water more slowly and, hence, remains more stable in moisture content. See next entry for summary of these experiments up to 1919.

254. PHILLIPS, E. P. Veld burning experiments at Groenkloof; second report. Pretoria, [Govt. printer, 1920?]. 7p. plates. (Union South Africa Dept. Agri. Sci. Bul. 17)

A summary of experiments on the effects of fire on vegetation at different seasons to see the extent that the practice of burning is beneficial or injurious. The author does not make any definite statement on controlled burning, but he has demonstrated that sheep can be kept alive for the greater portion of the winter on burned veld, whereas not a single animal could have survived on the unburned plots. The later the veld is burned the greater the number of shrubs in the resulting vegetation. Plots burned in May to July were typical grass veld by January of the following year; plots burned from September to November resulted in grass being backward and shrubs dominating the area.

255. PICKFORD, G. D. Influence of continued heavy grazing and of promiscuous burning on spring-fall ranges in Utah. Ecology 13(2): 159-171. April 1932.

"...Observations show that areas of spring-fall range, long protected from grazing and fire, such as cemeteries and field corners, support a good cover of plants palatable to livestock... Observation on promiscuously burned areas long protected from grazing indicate that burning tends to deplete the stand of perennial grasses and to allow annual grasses to increase sharply in density. The sagebrush cover is largely destroyed by burning. The total plant density of burned protected plots is about the same as on those totally protected. There is, however, a slight decrease in grazing capacity of burned protected plots. Areas subjected both to promiscuous burning and to heavy grazing show that these factors have seriously reduced the total density of the plant cover and depleted the stand of perennial grasses nearly 85 per cent. The sagebrush cover likewise has been reduced 80 per cent. Annual grasses and poor perennial and annual weeds are predominant. These changes in the plant cover due to fire and grazing have reduced the grazing capacity of the spring-fall range over 50 per cent..." --From author's summary in Biol. Abs. 6(11): 2499. Nov. 1932.

256. SAMPSON, A. W. Burning hay meadows and grazing lands. Breeder's Gaz. 63(9): 352. Aug. 31, 1910.

Firing of grazing lands under certain circumstances will render the new forage crop more accessible, but the actual carrying capacity will not be improved. Includes a discussion of effect of time of year when burning is practiced upon destruction or non-destruction

of the soil from fire. Under ordinary circumstances burning is wasteful, in depriving soil of natural fertilizers.

257. SAMPSON, A. W. Burning of pasture lands and its effects on forage production. In his Range and pasture management. N. Y., John Wiley and Sons, 1923, p. 216-240.

A chapter, with bibliography, on the history of burning in various parts of the country and the effects of burning pastures and woodlands. Conclusions include the author's opinion that burning is damaging to soil and forage production.

258. STAPLES, R. R. The effects of burning on the pasturage of natural grasslands, with special reference to South Africa. Union So. Africa Dept. Agr. Pan-African Agr. and Vet. Conf. (Pretoria) Papers, Agr. Sect., p. 202-210. 1929.

"Winter burning encourages the more valuable climax grassland spp... and summer burning, the inferior pioneer spp. A heavy summer burn is far more harmful than a slight burn; a January burn does more damage than a March or November burn. The nutritive ratio of the herbage is narrower on burnt as compared with unburnt grassveld, and is more suitable for the production of mills and wool, or the growth of young animals. Grassland burning results in greater extremes of soil temperatures and greater loss of moisture through direct evaporation. Burning results in the loss of a certain amount of N (about 10 lb. to an acre) and organic matter to the soil. Apparently all the advantages of burning, where this is necessary, and the least of the disadvantages, can be obtained by burning once in two or three years, or even at greater intervals under conditions of low rainfall." - From author's summary in Biol. Abs. 6(8/9): 2051. Aug./Sept. 1932.

259. STAPLES, R. R. Experiments in veld management; first report. Pretoria, Govt. printer, 1926. 35p. illus. (Union South Africa Dept. Agr. Sci. Bul. 49)

"In these experiments, 12 one-acre plots of grass veld climax consociation of a widely dominant species, Themeda triandra var. burchelli, were used. Each individual plot has had definite treatment since 1921, to ascertain the effects of grazing and mowing on botanical composition of this type of veld, which is remarkably sensitive to such factors as burning and grazing. T. triandra var. burchelli, contrary to what has often been maintained, is encouraged by winter burning. Even if instead of burning the excess of dead grass is got rid of by mowing, the grass tends to lose its vitality

and be replaced by an association of climax species, some of which are apparently much inferior to T. triandra in grazing value. A heavy summer burning tends to destroy T. triandra and favors inferior pioneer species such as Aristida junciformis. The causes of these changes and their practical significance in veld management are discussed." - Author's abstract in Biol. Abs. 2(9/11): 1485. Sept./Nov. 1928.

260. STAPLES, R. R. Studies in veld management; second report. Pretoria, Govt. printer, 1930. 31p. illus. (Union South Africa Dept. Agr. Sci. Bul. 91)

A summary of veld burning, grazing and mowing at the School of Agriculture at Cedara for 8 years, p. 10-12 summarizes 8 effects on the vegetation of burning during winter, which are beneficial, and 4 effects of burning during the summer, which are undesirable.

261. SWAIN, E. H. F. Rural fires. Australian Forestry Jour. 10(3): 69-73. Mar. 1927.

Gives the advantages of winter burning of pasture land and the evil effects of promiscuous burning of pasture land.

262. THERON, G. C. Veld-burning in the western Transvaal. illus. Farm. in South Africa 7(78): 244-254. Sept. 1932.

Grass from burned area contains a somewhat higher percentage of protein and minerals than that of unburned veld, which contains a proportion of old straw. But such burning has an adverse effect on the veld, according to 4-year experiments carried out at Potchefstroom.

263. THOMPSON, M. J. Effects of forest fires on land clearing and crop production. St. Paul, Minn., 1935. 23p. illus. (Minn. Agr. Expt. Sta. Bul. 220)

After the tremendous forest fire of October 12, 1918, this study was made on the effect of fire in reducing cost of clearing land and upon crop production. Comparisons of crop production on burned virgin soil and unburned virgin soil shows that sunflowers, hay and clover produced the same or greater on burned soil; oats and potatoes distinctly less on burned soil.

264. U. S. FOREST SERVICE. The western range... a great but neglected natural resource. Wash., Govt. print. off., 1936. 620p. illus. (U. S. 74th Cong., 2nd sess. Senate Doc. 199)

The effect of burning on forage production, p. 179-180; on erosion and floods, p. 323.

265. U. S. FOREST SERVICE. North central region (Region 9). The menace of woods fires in the central hardwood region. Milwaukee, Wis., [n. d.] 9p. mimeo.

Addressed to farmers primarily, pointing out that light burning destroys the best forage plants, lowers productivity of the soil, and destroys timber supply. Also points out that chinch bugs and cattle ticks are not eliminated by fire. Gives directions for safe use of fire in land clearing.

EFFECT ON FOREST ESTABLISHMENT AND EARLY GROWTH

("See also "Effect on Forest Succession", "Light or Controlled Burning", and entries 177, 196, 206, 219, 225, 243, 338, 341, 347, 355, 418, 433, 448.)

266. CHAMPION, H. G. Observations on some effects of fires in the chir (Pinus longifolia) forests of the West Almora division. Indian Forester 45(7): 353-364. July 1919. Reviewed in Jour. Forestry 18(6): 640-641. Oct. 1920.

The similarity of chir pine and western yellow pine makes these findings of especial interest. Effects noted after 1916 fires include: Chir trees up to two feet and more in diameter were killed outright, and more continue to die, month by month. Production of resin was largely diminished. Damage in smaller timber was practically complete. The author doubts if a one-season-old seedling ever survives a fire, and older seedlings which do survive are greatly weakened. (Comments by A. E. Osmaston appear in Indian Forester 46(3): 125-131. Mar. 1920. (See entry 385)

267. CHAPMAN, H. H. Forest fires and forestry in the southern states. illus. Amer. Forestry 18(8): 510-517. Aug. 1912.

The author holds that to keep fire entirely out of southern pine lands might result in their complete destruction. The danger of using fire is pointed out but intelligent use of it in promoting tree growth is recommended.

268. CHATURVEDI, M. D. Resistance of seedlings of sal (Shorea robusta) to burning. Allahabad, India. Supt. Govt. print., 1929. 8p. (United Provinces (India). Forest Res. Bul. 2)

"In the absence of browsing, fewer seedlings 3 years or more old will be killed by light burning before a heavy seed fall than will be replaced by recruitment. Repeated annual burning impedes natural regeneration even in the most favorable areas." - H. G. Champion in Biol. Abs. 7(6): 1418. June/July 1923.

269. CLEMENTS, F. E. The life history of lodgepole burn forests. Wash., Govt. print. off., 1910. 56p. illus. (U. S. Forest Serv. Bul. 79)

The forest fire history in the Estes Park region is reconstructed from 1707 to 1905, and the resultant character of the forest type described. "And it is by means of fire properly developed into a silvicultural method that the forester will be able to extend or restrict lodgepole reproduction, and lodgepole forests at will." - p. 56.

270. CONNAUGHTON, C. A. Fire damage in the ponderosa pine type in Idaho. "References": p. 51. Jour. Forestry 34(1): 46-51. Jan. 1936.

Data are presented on mortality in merchantable and reproduction stands, determined by a detailed survey, and on the delayed mortality which was determined by examination of a series of semi-permanent sample plots.

271. CRAIG, R. D. Clarion call for reproduction on cut-over lands. illus. Canad. Lumberman 42(11): 39-40. June 1, 1922.

Effects of fire, particularly upon reproduction, in the white and red pine forests in Ontario, and suggestion for slash burning which will leave the seed bed in good condition and do little damage to the polewood stand.

272. DAVIS, A. P. Forest villages in Burma. Indian Forester 49(12): 641-645. Dec. 1923.

Description of taungya villages, and how native farming (in which fire has a part) is combined with teak regeneration and weeding. Firing is done in April.

273. DUTT, S. L. Fire protection and natural regeneration. Indian Forester 33(10): 456-460. Oct. 1907.

Fire protection was introduced in a sal forest 28 years previous and reproduction became scanty. The author summarizes 7 points of advantages and disadvantages on fire-protected areas and on unprotected areas, with conclusion that protection is necessary.

274. ENEROTH, Olof. Försök rörande hyggesaskans inverkan på barrträdsfröets groning och plantornas första utveckling (The influence of ash of burned slash on the germination of conifer seed and the early development of seedlings). [German summary.] illus. Suomen Metsätieteellinen Seura. Commentat. Forest. 5: 1-67. 1931.

"Three series of germination tests were carried out under controlled conditions using garden loam and various types of forest humus as substrata. A range of pH was produced in the garden loam series by means of H_2SO_4 and NaOH. Various amounts of ash from freshly burned slash

were added to the forest humus series to produce a range of pH. Moisture content of the substrata was controlled. Additions of ash, even in excess of the amount occurring in nature after fires, did not hinder germination of pine and spruce. Addition of ash to poor raw humus layers favored germination. To a large extent the course of germination depends upon the chemical character of the substratum." - H. J. Lutz, in Biol. Abs. 7(2): 435. Feb. 1933.

275. FABRICIUS, Ludwig. Forstliche versuche. V. Die einwirkung von waldbrandasche auf samenkeimung und erste pflanzentwicklung (The effect of ashes from forest fires upon germination and early development of plants). Forstwiss. Centbl. 73(8): 269-276. April 15, 1929.

"Seed of Scotch pine, spruce, fir, larch, Austrian pine, beech, and birch were sown in sand in pots, with coverings of mold, sand, fine earth, and ashes from forest litter. In almost every instance, fewer seeds germinated under the ashes, and for every species fewer survived. Best germination and survival occurred with the covering of mold. It is concluded that Scotch pine and spruce are the best able to reproduce on sandy soils covered with ashes from forest fires; birch would be least capable of doing so were it not for t he enormous number of seeds; and, contrary to common belief, ashes hinder reproduction of all the common trees." - W. N. Sparhawk, in Biol. Abs. 4(4): 1214. Apr. 1930.

276. GARDNER, W. J. Results of a Rocky Mountain forest fire studied fifty years after its occurrence. Proc. Soc. of Amer. Foresters 1: 102-109. Nov. 1905.

The fire of 1850 on the Pike's Peak reserve destroyed about 75 per cent of the old forest. Reproduction after the fire was slow and irregular, and not more than 10 per cent of the land has been fully restocked, and, contrary to the usual occurrence, aspen did not as a rule come in first, to be succeeded by conifers. Engleman spruce predominates in the young forest, and comes in most promptly; red fir next, and the pines last of all.

277. GOTO, Shuzo. Untersuchungen über die natürliche waldverjungung bei Larix dahurica (Natural regeneration of L. dahurica). illus. Jour. Coll. Agr. Hokkaido, Imp. Univ. 18(5): 207-306. 1927.

"It has long been known that stands of L. dahurica usually follow a fire, but only recently was it determined that evidence of past fires is common in the virgin larch stands of Sakhalin. In these stands there is often an admixture of birch. Reproduction of spruce, birch, and fir is common, but even in pure stands the larch

does not reproduce itself and hence dies out after one generation, unless a fire occurs. Ground fires change the physical and chemical characteristics of the soil and make it more favorable for growth of larch. Larch established itself more readily on burned-over sample plots than on plots from which all grass and ground cover had been removed and which were cultivated. Pot experiments also showed 'burned' soil best for germination and growth. Burning prior to cutting is recommended for larch stands; when these operations precede a good seed year, natural reproduction of larch is fairly sure." -- H. Schmitz, in Biol. Abs. 3(1/3): 255. Jan./March. 1929.

278. HAIG, I. T. The effect of slash disposal on subsequent reproduction. Missoula, Mont., 1925. 3p. mimeo. (U. S. Forest Serv. Northern Rocky Mountain Forest Expt. Sta. Appl. Forestry Note 60)

Seedling reproduction in the western white pine type on a logged-over area on which slash was (1) unburned (2) lightly burned, and (3) heavily burned. The amount of reproduction on the heavily burned area was much greater than on the other two areas.

279. HICKS, H. G. Progress report of the forest administration in Coorg for 1929-30. Bangalore, Mysore Residency press, 1931. 32p.

"An accidental fire in March 1930 in a teak plantation 2 years old caused the appearance of a valuable crop of mixed species along with the teak. The area is better stocked after the fire than it was before, and weeds have been kept down." - M. V. Laurie, in Biol. Abs. 6(5): 1437. May 1932.

280. HOFMANN, J. V. The establishment of a Douglas fir forest. illus. Ecology 1(1): 49-53. Jan. 1920.

Includes the effect of fire in preparing the seedbed for Douglas fir germination, and the ability of the seed to survive forest fires.

281. HOFMANN, J. V. Laboratory tests on effect of heat on seeds of noble and silver fir, western white pine, and Douglas fir. table. Jour. Agr. Research 31(2): 197-199. July 15, 1925.

Due to inferior quality of true fir seeds used in the experiment, these tests are of interest mainly for results for pine and Douglas fir, which seeds remained viable at 200° and 220°F. dry heat and 160°F. moist heat. For a popular account of these experiments, see article by W. I. Hutchinson (Entry 285).

282. HOFMANN, J. V. Natural reproduction from seed stored in the forest floor. "Literature cited": p. 26. illus., plates. Jour. Agr. Research 11(1): 1-26. Oct. 1, 1917.

Results of a 5-year study on "single burns" and "repeated burns" of large areas in the Douglas fir region of Washington and cut-over lands of the Puget Sound region, with the conclusion that the principal factor in natural reproduction after fire is the seed stored in the duff. Hence, delayed germination and the degree of duff burn are the determining factors in reproduction after a single fire.

283. HORR, W. H. Some studies on the structure and behavior during germination of Gymnocladus canadensis Lam. illus. Kans. Univ. Sci. Bul. 17(2): 331-365. 1927.

"...Germination in nature occurs when seeded areas are burned over. High per cent of germination was obtained when seed coats were injured by filing, burning and soaking in acids." - M. C. Carlson, in Biol. Abs. 3(7/8): 1097. July/Aug. 1929.

284. HUBERMAN, M. A. Food reserves in Pinus palustris seedling roots, and their relation to annual fires. Thesis... Yale university. New Haven, Conn., 1933. 58p. typewritten. 7 pl. "References": p. 51-58.

Microchemical and macrochemical analyses of longleaf pine seedlings of the 1924 seed crop from burned and unburned areas in southern Mississippi. Starch is stored in the roots in winter, from seedlings of both burned and unburned areas. Total carbohydrates and non-reducing sugars were more abundant in all parts of the seedlings from the unburned than from burned areas. The reverse was true in the case of reducing sugars.

285. HUTCHINSON, W. I. How tree seeds live through forest fires. illus. Pop. Mech. 38(6): 901-902. Dec. 1922.

An account of J. V. Hoffman's experiments on how much heat Douglas fir seed can stand and keep its viability, and the practical importance of these experiments with respect to natural regeneration. (See entry 281.)

286. ISAAC, L. A. Concerning the reburning of Douglas fir cut-over land. In U. S. Forest Serv. Pacific Northwest Forest Expt. Sta. Forest Res. Note 7, 1931, p. 3.

Indicates the extent of second burns and their devastating effect upon seedlings which have partially restored the area after the first burn.

287. ISAAC, L. A., and Hopkins, H. G. The forest soil of the Douglas fir region, and changes wrought upon it by logging and slash burning. "Literature cited": p. 278-279. April 1937.

A study made of a typical Douglas fir soil on the Wind River Experimental Forest near Carson, Washington. Logging in Douglas fir usually leaves a great accumulation of slash, and burning it produces extremely high temperatures lasting for several hours. It reduces the immediate fire hazard but results in almost complete destruction of the duff layer, and blackening of the surface soil increases heat-absorptive capacity sufficiently to cause the increased temperature to kill seedlings, while on adjacent unburned soils temperature remains so low as to cause no such injury to seedlings. This study has led to the conclusion that the harmful effects of ordinary slash fires more than outweigh any beneficial effects it may have on productivity of Douglas fir soil. The study will continue, checking seedling establishment on burned and unburned portions of a homogeneous site, since seedling behavior is the only certain measure of soil productivity.

288. ISAAC, L. A., and Meagher, G. S. Natural reproduction on the Tillamook burn two years after the fire. Portland, Oreg., Pacific Northwest Forest Expt. Sta., 1936. 19p. col. map. mimeo.

A study made by the Pacific Northwest Forest Experiment Station to (1) gather data on status of reproduction on the burn and (2) on natural reproduction of Douglas fir and associates--seed survival, dissemination and seedling establishment after one fire and after repeated fires.

289. ISAAC, L. A., and Meagher, G. S. Natural reproduction on the Tillamook burn four years after the fire. Portland, Oreg., Pacific Northwest Forest Expt. Sta., 1938. 15p. map. mimeo.

A continuation and supplement to preceding entry.

290. ISAAC, L. A. Seedling survival on burned and unburned surfaces. Jour. Forestry 28(4): 569-571. Apr. 1930. Abstracted by P. C. Wakeley in Biol. Abs. 5(4): 1158. Apr. 1931. Appears also in Forest Research Notes (U. S. Forest Serv. Pacific Northwest Forest and Range Expt. Sta.) 3: 3-4, Oct. 30, 1929.

A study of Douglas fir seedlings on natural soil surfaces and surfaces blackened by slash burning demonstrated how the extra heat on charcoal-blackened soil killed the seedlings, while on the unburned surface there was only 16 per cent loss.

291. JERRAM, M. R. K. The effect of fire, shade, and injury on the growth of Pinus longifolia seedlings. illus. Indian Forester 48(12): 644-647. Dec. 1922.

Seedlings germinating soon after fire show much better growth than those from unburned areas, especially when the seedlings have some shade. The author does not believe the beneficial effect is due to the wood ashes alone, but believes that bacteria, both beneficial and detrimental to growth, are destroyed by heat but that the former re-establish themselves more quickly than the latter. From this it appears that burning loses much of its value if not followed immediately by seeding.

292. JUDD, C. S. Douglas fir and fire. Proc. Soc. Amer. Foresters 10(2): 186-191. Apr. 1915.

The influence of forest fires in creating favorable conditions for the development of Douglas fir stands. The most favorable effect of forest fires in this respect is the burning off of the humus so that the mineral soil is exposed, and Douglas fir regenerates itself to the almost complete exclusion of other competitive and dominating species.

293. KÄLLSTRÖM, Hj. Tvenne exempel på bränningens goda inverkan (Two examples of the good influence of burning). Skogen 13(5): 162-163. May 1926.

"In 2 cases where poor morainal pine ridges burned following logging, natural reproduction of pine was favored, and the present stands show great improvement in site quality over the previous conditions." - H. I. Baldwin, in Bot. Abs. 1(6): 932. Oct. 1927.

294. KESSELL, S. L. Fire control in Australia. British Empire Forestry Conf., 3: 741-748. 1928. Appears also in Australian Forestry Jour. 11(3): 99-105. Sept. 1928.

Damage from bush fires in Western Australia is not noted by the casual observer because the foliage is rapidly replaced, even after a crown fire. The rôle of fire in the regeneration of Eucalypts included: (1) Scrub and debris is burnt back, exposing mineral soil. (2) A complete and simultaneous seedfall is caused by the heat of the fire. (3) Seedbed is prepared so that seedlings have an even start in their competition with underbrush.

295. KIENHOLZ, Raymond. Revegetation after logging and burning in the Douglas fir region of western Washington. illus. Trans. Ill. Acad. Sci. 21: 94-108. 1928.

An experiment in the Douglas fir region of western Washington on revegetation after logging and burning showed that vegetation varied directly with the length of time after burning. Plots severely burned showed less

vegetation than those moderately burned. The species were divided into three groups: herbaceous species, shrubby species, and weed species, the latter not present in the original stand. The herbaceous species start high on the recently burned plots, but gradually decrease. The shrubby species start low, but gradually increase with age. The weed species start low, but increase rapidly. The species frequency ratio shows that the vegetation is in an unstable condition.

296. LARSEN, J. A. Natural reproduction after forest fires in northern Idaho. illus. Jour. Agr. Research 30(12): 1177-1197. June 15, 1925.

A study made in 1923 on the Coeur d'Alene National Forest on areas burned once (in 1910) and on areas burned twice at different intervals (in 1870, 1889, 1910 and 1919). Among the factors studied was intensity and difference in site or stand conditions affecting natural restocking. Among the conclusions are: When a single fire destroyed a mature forest, natural stocking was prompt, uniform and complete, consisting largely of western white pine. In case of double burns, restocking was deficient. The factor of time which elapses between a first and second burn is discussed, as well as the influence of grass, which springs up after burns, upon natural reproduction. The effect of double burns on erosion and surface drought is noted. A short note about these observations appears also in Service Bul. (U. S. Forest Serv.) 7(38): 5. Sept. 24, 1923. Summary appears under title "Natural reproduction on single and double burns in northern Idaho", in U. S. Forest Serv. Northern Rocky Mountain Forest Expt. Sta. Appl. Forestry Note 52.

297. LARSEN, J. A. The study of natural reproduction on burned areas. Jour. Forestry 26(3): 332-337. Mar. 1928. Abstracted by P. C. Wakeley in Biol. Abs. 3(4/6): 868. Apr./June 1929.

After an area is burned the predominate factors influencing natural reproduction are increased air and soil temperature, intensified insolation, frost, evaporation and soil desiccation, the invasion of competing vegetation, insect and fungus activities resulting from the fire, and often, prolonged denudation and erosion.

298. LARSON, Th., Klingberg, H., [and] Sörensen-Ringo, H. Några iakttagelser och rön fran Spannarboda brandfält (Some observations and experiments on the Spannarboda burn). illus. Skogen 13(8): 217-236. Aug. 1926.

"Investigations were made of the results of artificial regeneration on a burn of over 7000 acres. Immediately after the fire (in 1914) Betula verrucosa was sown

broadcast, and later Pinus silvestris and Pinus excelsa were sown in furrows. On the better sites with clay soil birch grew well and often suppressed the pine; on fine sand and morainal soil, however, birch failed to form an acceptable stand. Pine made very good growth, especially on the latter soil. Spruce in all cases failed; it should not be used for reforesting after fires. As a soil improver birch excelled pine; under the birch the humus was disintegrating more rapidly, herbaceous species indicative of good site quality were more abundant, and the flora was richer in its species. Fern (Pteris), an indicator of poor soil conditions, was suppressing all other vegetation on some areas. Broadcasting birch seed on good soils after fire is recommended even where there is no good market for birch wood, since birch prepares the way for other species."
-- H. I. Baldwin, in Bot. Abs. 1(6): 932. Oct. 1927.

299. LEACH, Walter. Forest fire in thinned oak polewood. fig. Pa. Dept. Forests and Waters, Serv. Letter 6(6): [1-2]. Feb. 7, 1935.

Results of a fire in Kettle Springs plateau, tabulating losses in thinned and unthinned areas. Mentions sprouting of oak and pitch pine, even in the badly burned thinned plots.

300. LEAVITT, Clyde, Compiler. Forest protection in Canada, 1913-1914. Toronto, Pub. by Canada commission of conservation, committee on forests, 1915. 317p. illus.

The effect of fire on Douglas fir reproduction, p. 86-87; Effect of logging with burning upon reproduction of other species, p. 222-227.

301. M., J. Fire protection in the teak forests of Burma. Indian Forester 30(9): 414-419. Sept. 1904.

Examples are cited of mature teak forests with no regeneration, because of the shade and because the seeds cannot reach mineral soil. These areas have been protected. In similar unprotected areas many young teak seedlings were found. On the other hand, stands with many teak saplings and few mature trees need fire protection for the benefit of the young trees.

302. McARDLE, R. E., and Isaac, L. A. The ecological aspects of natural regeneration of Douglas fir in the Pacific Northwest. Proc. Pac. Sci. Cong., 5th (Canada) 5: 4009-4015. 1933. (1934)

Includes slash burning and its relation to Douglas fir regeneration, reduction of soil fertility and soil moisture, and creation of type of cover competitive to seedlings. Slash fires in this area appear, however, to reduce rodents and insects, and to remove excessive debris and vegetative cover to permit natural restocking.

303. McCARTHY, E. F., and Sims, I. H. The relation between tree size and mortality caused by fire in southern Appalachian hardwoods. Jour. Forestry 33(2): 155-157. Feb. 1935.

"Forest fires seldom completely destroy hardwood stands in the southern Appalachians. Ordinarily a fire results in high mortality in the smaller diameter classes and progressively less in the larger classes." --from introd., p. 155.

304. MacKINNEY, A. L. Effects of a light fire on loblolly pine reproduction. Asheville, N. C., 1935. 2p. tables. mimeo. (U. S. Forest Serv. Appalachian Forest Expt. Sta. Tech. note 9)

Table shows cumulative mortality 7 weeks after, 26 weeks after, and 50 weeks after a light fire. Mortality of reproduction was very high, and continued for more than 6 weeks after the fire.

305. MALME, G. O. A. N. Om frönas groning hos Geranium bohemicum L (Germination of G. bohemicum). Bot. Notiser 1928 (3): 221-226. 1928.

"...These results support the theory advanced by Almquist (1899) that the rapid growth in burned-over areas is due to the excessive heat of the forest fires, which stimulates germination of seed long buried in the soil." - From author's abstract (transl. by M. N. Levine), in Biol. Abs. 3(9/11): 1679. Sept./Nov. 1929.

306. MARSHALL, Robert. The life history of some western white pine stands on the Kaniksu national forest. Northwest Sci. 2(2): 48-53. 1928.

"Repeated fires may lead to the establishment of a forest containing several distinct age classes. In unburned forests distinct age classes sometimes result from insect injury. Even-aged stands occasionally follow severe fires if regeneration is prompt." - H. J. Lutz, in Biol. Abs. 4(1): 194. Jan. 1930.

307. MATTOON, W. R. Longleaf pine. Wash., Govt. print. off., 1922; rev. 1925. 50p. illus. (U. S. Dept. Agr. Dept. Bul. 1061)

p. 11-13, and p. 44-46 are on adverse effects of fire upon growth, reproduction and turpentining.

308. MOLCHANOV, A. Estestvennoe lesovosobnovlenie na gariakh (Natural reproduction on burned areas). tables. Lesnoe Khoziaistvo I Lesoeksploaiatsiia (U.S.S.R.) 7: 40-42. July 1934; 8: 44-46. Aug. 1934.

Part of an article "Forest fires, and their influence on the forest and reforestation", on the work of M. E. Tkachenko, and S. V. Alekseev, at the Plesetsky LTKX (formerly Northern Experimental Forest). Includes a

short summary of other Russian literature on the subject. Translation by C. S. Beliavsky[1s], in the U. S. Forest Service Library.

309. PEARSON, R. S. Fire protection and the use of drums as fire alarms. Indian Forester 30(7): 306-308. July 1904.
Though fire is beneficial to teak in some generation areas it has a most damaging effect in the dry-zone forests.

310. PERRY, G. S. Effect of fire on seedlings. Pa. Dept. Forests and Waters. Serv. Letter 6(20): 2-3. May 16, 1935. Appears also in Forest Leaves 25(3): 7. July 1935.
Germination tests on Norway spruce, red pine and white pine seeds sown on burned and unburned soils indicated that pines thrive somewhat better on unburned soils and Norway spruce definitely thrives better on burned soils. More than 5 times as many seedlings perished in burned soil as in the unburned, despite greater root lengths in the former. None of the trees showed a stimulus in growth due to fertility liberated by fire.

311. PERRY, W. J. Those "harmless" surface fires. illus. Amer. Forests 32(393): 536-538. Sept. 1926.
Results of repeated light fires upon reproduction in western yellow pine type.

312. RENVALL, August. Mäntymetsän elinehdot sen pohjoisrajalla sekä tämän rajan alenemisen syyt (Life conditions of pine forests of the Northern border of the pine zone, and the factors influencing decrease of this zone). Acta Forestalia Fennica 11: 7-128. 1919.
Includes the effect of fire on pine reproduction in parts of Finland, and the effect of fire between seed years.

313. RIKLI, M. Erste Stadien der Walderneuerung nach Waldbränden (Early stage of reproduction after forest fires). Schweiz. Ztschr. Forstw. 80(2): 33-38. Feb. 1929.
Includes the effect of fires on soil flora, and upon reproduction in brushwood forests in Corsica, and Pinus pinaster and cork oak forests in southern France.

314. ROBERTSON, F. Fire-resistant properties of sal. Indian Forester 52(2): 76-77. Feb. 1926.
"After having burned annually for about 30 years, a fire line 100 feet wide was abandoned, almost immediately sal appeared in a dense, uniform stand and rapid growth has been the rule except on clay soil. This is in contrast to the poorly stocked, slow-growing forest on the adjacent protected areas." - E. N. Munns, in Bot. Abs. 1(1): 139. Dec. 1926.

315. RUBNER, Konrad. Urwaldfragen (Questions referring to the virgin forest). Forstarchiv 6(8): 145-154. April 15, 1930.
Includes a discussion of the behavior of pine and spruce with regard to regeneration after a fire.

316. SCHMIDT, Werner. Waldbrandboden und Keimling (Burned forest soil and seedling). Deut. Forstw. 11(36): 139-190; 11(37): 193-194. 1929.
Physiological relations between burned surface and plants are dealt with, with references to other German researches on the subject. U. S. Forest Service Library has translation into English by C. P. de Blumenthal. (Div. of Silvics Trans. 278)

317. SMYTHIES, E. A. Notes on the twisted fibre in chir pine. Indian Forester 41(3): 69-75. Mar. 1915.
Fire in chir during its early growing period is a primary cause of twisted fibre. The three kinds of damage which cause twisted fibre are fire, grazing, and removal of the humus.

318. SMYTHIES, E. A. Some aspects of fire-protection in chir forests. Indian Forester 37(1/2): 54-62. Jan./Feb. 1911.
The author's conclusions: (1) That after years of burning, fire-protection gives an extraordinary and universal stimulus to regeneration. (2) That successful regeneration is possible under the most favorable conditions without fire-protection. (3) That long-continued fire-protection has an adverse effect on regeneration. Reply by A. E. Osmaston appears in Indian Forester 60(8): 387-391. Aug. 1914.

319. TROUP, R. S. Fire protection in the teak forests of Burma. tables. Indian Forester 31(3): 138-146. Mar. 1905.
The results of an enumeration of teak seedlings and young poles on similar adjoining areas, one burnt annually and the other protected from 1872 to date (1905). Replies to the article by F. J. Branthwaite, W. R. Fisher, and J. W. Oliver appear in the same journal for July, 1905, p. 383-388.

320. U. S. FOREST SERVICE. Lake states forest experiment station. Damage to advance growth by slash disposal. St. Paul, Minn., 1934. 1p. mimeo. (Tech. Note 77)
Includes damage by 6 slash disposal methods, 3 of which involve burning.

322. U. S. FOREST SERVICE. Lake states forest experiment station. Spring fires on the jack pine plains. St. Paul, Minn., 1931. 1p. mimeo. (Tech. Note 44)

"Early spring fires on the jack pine plains, such as the one recorded, which was typical, kill about 80 per cent, and more or less seriously damage 90 per cent of the stand. The greatest damage done is to small trees or reproduction. Spring fires may cause little or no damage to merchantable trees but they are responsible for lack of reproduction in older stands, thus jeopardizing the future of the forest." - from conclusion.

323. U. S. FOREST SERVICE. Pacific northwest forest experiment station. Seedling survival on burned and unburned surfaces. In its Forest Research Note 3, 1929, p. 3-4.

"... the sudden killing of all seedlings by heat on the charcoal surface practically presages inevitably heavy losses (on one-year-old Douglas fir seedlings) for freshly burned areas, and demonstrates how the color of the surface alone may spell success or failure for a crop of Douglas fir seedlings." - from p. 4.

324. U. S. FOREST SERVICE. Pacific northwest forest experiment station. Survival of one-year-old Douglas fir seedlings. In its Forest Research Note 2, 1929, p. 5-6.

The variation in surface temperature, with the attendant loss of seedlings, on natural soil surfaces and on soil surfaces blackened by slash burning.

325. U. S. FOREST SERVICE. Southern forest experiment station. Effect of fire in second-growth longleaf and slash pine varies widely under different conditions. In its Southern Forestry Note 4, 1933, p. [1-2]. Also appears in Serv. Bul. (U. S. Forest Serv.) 18(7): 8. March 26, 1934.

Résumé of experiments by the station after fires during the growing season. Gives percentages of mortality for different classes and age groups in 1- and 3-year rough.

326. WACKERMAN, A. E. Minnesota's only hemlock gone. Jour. Forestry 23(7/8): 703-704. July/Aug. 1925.

Among results of the Cloquet fire in 1918 is that the only known stand of hemlock in Minnesota was burned so severely that there is little chance that it will reproduce itself.

327. WAKELEY, P. C. The inside story of slash pine on areas subject to frequent fires. Forest Worker (U. S. Forest Serv.) 7(1): 11-12. Jan. 1931.

Narrative of how a superlative stand of slash pine

seedlings on 1000 acres, near the Bogalusa Branch Forest Experiment Station, which was just above the grass in 1928 succumbed to a series of fires.

328. WALKER, H. C. Fire protection in the teak forests of lower Burma. illus. Indian Forester 29(8): 293-298. Aug. 1902; 29(12): 554-562. Dec. 1903; 30(8): 366-370. Aug. 1904; 30(11): 518-522. Nov. 1904.

A series of articles on the results of fire on teak reproduction, and a discussion of India's fire-protection policy, and its effect on other silvicultural matters. Replies to these articles include: Gleadow, F., in Indian Forester 30(5): 207-208. May 1904; Stebbing, E. P., in Indian Forester 29(2): 75-80. Feb. 1903; Manson, F. B., in Indian Forester 30(4): 155-156. Apr. 1904 (this article contains an extract from the diary of A. E. Ross, Deputy Conservator of forests, on damage); Unsigned article in Indian Forester 29(10): 389-390. Oct. 1902.

329. WEDDELL, D. J., and Ware, L. M. The effect of fires of different frequencies on the survival of different species of pines. In Ala. Agr. Expt. Sta. Ann. Rept., 47th, 1936, p. 28-29.

Studies on survival of the four principal pine species in the South after burning.

330. WYMAN, Lenthall. Results from sample plots in southern pines experiments. Jour. Forestry 20(7): 780-787. Nov. 1922.

A check-up 5 years later on 5 sets of sample plots laid out in 1915 on Urania Lumber company lands in Louisiana, to secure data on effects of fire and grazing on longleaf pine reproduction. Tentative conclusions on the Roberts plots are: "Careful winter burnings begun when the seedlings are a little more than a year old, do not kill longleaf pine until the majority of the seedlings have reached six inches in height. This is about the eighth year in the case of repeated burned stands. After this height is reached a considerable mortality--between 10 and 20 per cent--may be expected in each fire. 2. Repeated fires stunt the growth of seedling trees, reducing the rate of growth by 50 per cent for six years at least. 3. Six to 18 inches represent the stage of growth for longleaf pine seedlings when fires do the maximum amount of damage. 4. Complete protection from fire must be continued for more than 6 years where grazing has been excluded. Otherwise the increased amount of inflammable material resulting from the no-grazing policy will cause a disastrous fire. 5. The leaf-blight disease has killed a number of seedling longleaf pines and is a factor in obtaining reproduction. 6. This

disease which renders infected seedlings more susceptible to fire than are healthy seedlings may be partly controlled by fire." - from p. 787.

EFFECT ON GROWTH OF OLDER STANDS

(See also entries 200, 303, 357, 370, 380, 382, 433, 440, 441.)

331. ASHE, W. W. The forests, forest lands and forest products of eastern North Carolina. Raleigh, N. C., State printer, 1894. 128p. illus. (N. C. Geol. Surv. Bul. 5)
p. 52-72 is on destructive work of fire in longleaf pine region and why fire should be excluded. Notes especially the retardation of height growth by fire.

332. BARRETT, L. I. Fire damage to mature loblolly pine stand. Naval Stores Rev. 38(18): 11. Aug. 4, 1928.
Research at the Southern Forest Experiment Station on annual rings revealed huge growth losses resulting from fire in standing timber.

333. CRAIGHEAD, F. C. Abnormalities in annual rings resulting from fires (with comments by E. N. Munns). illus. Jour. Forestry 25(7): 840-842. Nov. 1927.
"Defoliation by a fire in June 1924, decreased or totally inhibited formation of wood during the balance of 1924 and during 1925, in western yellow pine at Northfork, California. Similar observations are recorded from North Carolina." - P. C. Wakeley, in Biol. Abs. 3(1/3): 254. Jan./March 1929.

334. DEMMON, E. L. What the forest fires of 1927 did to the pines on Georgia cut-over lands. chart. Naval Stores Rev. 38(35): 14-15. Dec. 1, 1928.
A study made by the Southern Forest Experiment Station one year after a severe fire, to determine damage to longleaf and slash pine, turpentined and not turpentined, in areas formerly protected and periodically burned over.

335. HINE, W. R. B. Hogs, fire and disease versus longleaf pine. illus. South. Lumberman 119(1544): 45-46. May 2, 1925.
Damaging effects of these factors on diameter and height growth.

336. HOW a tree tells the story of forest fires. illus. Sci. Amer. 128(3): 183. Mar. 1923.
Illustration of cross section of a 244-year-old tree showing fire scars, gnarled rings, etc.

337. HOWE, C. D. Some aspects of forest investigative work in Canada. Proc. Int. Cong. Plant Sci., Ithaca, N. Y., 1: 701-712. 1926. (1929)
Includes research work on growth and yield on burned and unburned areas.

338. MacKINNEY, A. L. Longleaf pine subjected to thirteen years' light burning show retarded growth. Forest Worker (U. S. Forest Serv.) 7(5): 10-11. Sept. 1931.

Average diameter at breast height of all trees on the annually burned plot was 4.4 inches; that of all the trees on the protected plot was 5.1 inches. Figures are given for difference in increment, in volume of peeled wood, and results show that although loblolly pine reproduction ranging from 1 to 14 feet in height occurs in an opening on the protected plot, not a single loblolly pine is on the burned plot, although there was a comparable hole in the stand in the burned plot. Grass with an approximate density of 0.8 covers the burned area; the presence of 3 to 5 inches of litter and one-half inch of humus on the protected area, and the greater density of the crown canopy have prevented the establishment of grass and herbaceous cover on the protected area.

339. MacKINNEY, A. L. Mortality in longleaf pine pole stand after a hard fire. table. Service Bul. (U. S. Forest Serv.) 17(22): 3. Oct. 23, 1933.

Examinations two months and eleven months after the fire. Table shows percentage of trees that died in each of 5 defoliation classes.

340. MacKINNEY, A. L. Some effects of three annual fires on growth of longleaf pine. table. Jour. Forestry 32(8): 879-881. Nov. 1934.

Results of an experiment at the Appalachian Forest Experiment Station, using 3 groups of plots, burned and unburned. In every diameter class except the 8-inch class the trees on annually burned areas grow more slowly in basal area than on the unburned areas. Reduction of height growth was also evident but was not so striking.

341. MacKINNEY, A. L. Thirteen annual fires in the longleaf pine type. Service Bul. (U. S. Forest Serv.) 15(37): 2-4. Sept. 14, 1931.

Fifty longleaf pine saplings were selected on two contiguous areas in South Carolina to show the effect of annual fire on growth. After thirteen years the reduction in height growth due to annual burning amounted to 19 per cent and during the ten-year period 1919-1929 the reduction in diameter growth amounted to 9 per cent and the reduction in annual volume growth amounted to 22 per cent. A comparison of all the trees on both plots shows that the average d. b. h. on the burned plot is 4.4 inches and on the unburned 5.1 inches, the difference in average height is 7.4 feet, and the annual reduction in volume growth amounts to 51.6 cu. ft. per acre. In addition, the burned plot is without reproduction, while the unburned plot is characterized by reproduction in the openings.

342. MELROSE, G. P. The autobiography of a tree. illus. Illus. Canad. Forest & Outdoors 19(8): 512-513. Aug. 1923.
Chart shows growth rings and the effect of fire upon them.

343. MELROSE, G. P. History written in trees. illus. Amer. Forestry 29(355): 414-415. July 1923.
Fire damage in mature timber and young growth. Photograph shows cross section of a fire scar.

344. PAUL, B. H. Influence of fires on growth of pine. illus. South. Lumberman 122(1583): 41. Jan. 30, 1926.
Illustration of cross sections of wood showing the effect of annual burning of the forest upon growth of shortleaf pine.

345. RODGER, H. The effects of fire in teak forests. plates. Indian Forester 33(1): 17-18. Jan. 1907.
Five photographs representing the life history of a fire-injured tree, with explanatory notes.

346. SHEPARD, H. B. Supposedly harmless surface fires damage old growth forests. In U. S. Forest Serv. Pacific Northwest Forest Expt. Sta. Forest Research Note 5, 1931, p. 3.
"A composite picture of two surface fires in Coast Range studies shows, that trees 15 inches d. b. h., 13 per cent of the Douglas fir, 71 per cent of the hemlock, 90 per cent of the spruce and 100 per cent of the balsam fir, by volume, died as a direct result of supposedly innocuous surface fires." - from paragraph 3. This damage did not show up for more than a year.

347. WAKELEY, P. C. Effect of a single winter fire on planted slash pine. Forest Worker (U. S. Forest Serv.) 7(2): 11. Mar. 1931.
One growing season after a fire (on a slash pine plantation large enough to be past the worst danger from burning) workers of the Southern Forest Experiment Station and the Mississippi Commission of Forestry found that one winter fire may kill about one-tenth of the trees and reduce the following season's height growth of the survivors by 25 per cent or more.

DIRECT AND INDIRECT EFFECT ON MERCHANTABLE TIMBER

(See also "Fire Damage Appraisal" and entries 179, 244, 303, 332, 334, 344, 433, 445.)

348. ABELL, M. S. Much heart rot enters white oaks through fire wounds. Forest Worker (U. S. Forest Serv.) 8(6): 10. Nov. 1932.
Summary of studies by Nelson, Sims, and others on fire and decay. (See also entries 383 and 384.)

349. ANDERSON, I. V. Fire scarred ponderosa pine - what is the loss? illus. Timberman 35(6): 14-15, 26. Apr. 1934.
Includes tables showing loss in merchantable timber due to damage by fire.

350. BEAL, J. A., Kimmey, J. W., and Rapraeger, E. F. Deterioration of fire-killed Douglas fir. Timberman 37(2): 13-17. Dec. 1935.
A digest by J. E. Lodewick, of a detailed progress report.

351. BOYCE, J. S. The dry-rot of incense cedar. Wash., Govt. print. off., 1920. 58p. illus. "Literature cited": p. 57-58. (U. S. Dept. Agr. Bul. 871)
p. 38-39 shows percentage of trees studied having fire scars, and their effects. "Considering all the severe cull cases as 100 per cent, it is found that fire is responsible for 84 per cent... Furthermore, 81 per cent of the total volume of cull caused by dry-rot resulted from infections entering through fire scars." --from p. 45.

352. BOYCE, J. S. Fire scars and decay. illus. Timberman 22(7): 37. May 1921.
Notes on analyses of fire-injured trees of the Pacific Coast in relation to fungal diseases.

353. BOYCE, J. S. Forest pathology. 1st. ed. N. Y., McGraw-Hill book co., 1938. 600p. illus. Bibliographies at end of chapters.
Includes section on relation of fire scars to decay, and deterioration of fire-killed timber. Also notes on use of fire for control of brown spot disease of pine.

354. BRADNER, M. I., and Anderson, I. V. Fire-damaged logs - the loss? illus. Timberman 31(7): 38-44. May 1930.
Analysis of grade depreciation and volume losses of fire-killed Idaho white pine.

355. CHAPMAN, H. H. The causes and rate of decadence in stands of virgin longleaf pine. Lumber Trade Jour. 84(6): 11, 16-17. Sept. 15, 1923.
Fire and damage by hogs and their effects on longleaf pine in the South.

356. COPE, J. A. Loblolly pine in Maryland, "a handbook for growers and users." Baltimore, Md., State dept. forestry, 1923. 96p. illus.
p. 20-23 is on fire, and determining the extent of fire damage in this species.

357. CRAIGHEAD, F. C., and St. George, R. A. Some effects of fire and insect attack on shortleaf pine. Forest Worker (U. S. Forest Serv.) 4(2): 11-12. March 1928.
U. S. Bureau of Entomology check made on a burned-over area on the Pisgah National Forest in North Carolina. Defoliation due to heat from the burning litter was most common type of injury. Data was kept on insect damage, height growth, resin duct restriction, and reduction of ratio of summer wood to spring wood, all due, either directly or indirectly, to fire.

358. DEMMON, E. L. Fire damage in virgin southern pine. chart. South. Lumberman 124(1615): 47. Sept. 11, 1926.
Data collected by the Southern Forest Experiment Station on the amount and character of fire-scarring in longleaf and shortleaf pine types in several virgin areas in Texas, Louisiana, Arkansas, and Mississippi. 25 per cent of the longleaf and 11.5 per cent of the shortleaf were fire-scarred. Article points out the reasons why longleaf was more frequently injured.

359. GARVER, R. D. Price of fires in shortleaf pine. South. Lumberman. 131(1704): 39. May 26, 1928.
An economic study of damage from fire in merchantable timber.

360. HEDGCOCK, G. G. Fire-scar damage in woodlands heavy. In U. S. Dept. Agr. Yearbook, 1926, p. 363-364.
19 per cent of the volume of eastern hardwoods is often lost because of decay, and 90 per cent of butt rots enter through fire wounds.

361. HEPTING, G. H. Decay following fire in young Mississippi Delta hardwoods. Wash., Govt. print. off., 1935. 32p. illus. "Literature cited": p. 31-32. (U. S. Dept. Agr. Tech. Bul. 494)
Surface fires, no matter how light, have a devastating effect upon young growth. This effect of fire scars on hardwoods are (1) Mechanical weakening because of

cessation of increment over the scar (2) the interruption in the physiological functions of trans-location of food, nutrients and water and (3) exposure to entrance of wood-destroying fungi and insects. In this study of 602 fire-scarred hardwoods a definite relation was found between rate of decay and each of these factors: age of tree; percentage of tree circumference scarred; diameter at the time of scarring; present diameter; fungus causing decay. 9 species of Delta hardwoods were analyzed as to susceptibility to initial infection, rapidity of healing, etc.

362. HEPTING, G. H., and Hedgcock, G. G. Relation between butt rot and fire in some eastern hardwoods. Asheville, N. C., 1935. 2p. table. mimeo. (U. S. Forest Serv. Appalachian Forest Expt. Sta. Tech. Note 14)

Results of a study of 5,882 trees cut in 8 eastern states show that 97 per cent of basal wounds are caused by fire. If fire were eliminated from these forests it would reduce the total cull volume for these hardwoods to about one-third of its present total.

363. HEPTING, G. H., and Hedgcock, G. G. Relation of cull per cent to tree diameter and to percentage of trees with basal wounds in some eastern hardwoods. Asheville, N. C., 1935. [4]p. chart. mimeo. (U. S. Forest Serv. Appalachian Forest Expt. Sta. Tech. Note 16)

A later note continuing a study on 5,882 hardwoods in the Eastern U. S., of which 97 per cent of their basal wounds were caused by fire. (See also preceding entry.)

364. HIDDEN bole injuries caused by fire. Service Bul. (U. S. Forest Serv.) 6(30): 2-3. Oct. 16, 1922.

A discussion of (1) old fire scars (2) extensions of old fire scars and (3) new lesions, noted on the White Horse burn of the Modok National Forest, one and one-half years after the fire.

365. HUBERT, E. E. Outline of forest pathology. N. Y., John Wiley and sons, 1931. 543p. illus. References at end of chapters.

On p. 24 in section "The principal influencing factors", the author says, "Fire scars are responsible for most of the heart-rot in our standing timber, ranking higher than any other wound factor."

366. KAUFERT, F. H. Fire and decay injury in the southern bottomland hardwoods. Jour. Forestry 31(1): 64-67. Jan. 1933.

A study made of fire-scarred hardwoods of the Mississippi Delta. It is estimated that from 90 to 95

per cent of the decay in merchantable hardwoods has resulted from fire, and immature timber suffered even more severely.

367. KESSELL, S. L. Fires in eucalypt forests, by S. L. K. Australian Forestry Jour. 3(12): 373-374. Dec. 1920.
Emphasizes the damage that creeping bush fires do to eucalypts, in spite of its fire-resistant character. The author compares conditions in Southern France, where fire protection is practiced, to many parts of Australia. A note also on the Jarrah belt in Western Australia and its plight due to repeated bush fires.

368. LACHMUND, H. G. Bole injury in forest fires. Jour. Forestry 21(7): 723-731. Nov. 1923.
Three types of bole injury--old fire scars, extensions of old fire scars, and new lesions--are discussed in connection with making damage appraisals after a fire. In a study of sample plots on the Modok National Forest hidden extensions and new lesions were found to be of more importance than is generally recognized.

369. LACHMUND, H. G. Some phases in the formation of fire scars. Jour. Forestry 19(6): 638-640. Oct. 1921.
Fire scars may remain hidden for 10 years and more after injury and, although they are negligible as a direct cause of loss, they are of importance in providing a point of entrance to fungi. In studying four species of western trees it was found that incense cedar is most susceptible to fire injury, yellow pine is next, while Douglas fir and white fir are more fire-resistant.

370. LEETE, B. E. Forest fires - an area class study. tables. Ohio Agr. Expt. Sta. Bimo. Bul. 18(163): 107-109. July-Aug. 1933.
Gives, among other figures, damage to woods of fires of 6 size classes. Figures in percent of damage, and cost per fire.

371. LENTZ, G. H. Loss in merchantable red gum due to two fires. illus. South. Lumberman 135(1756): 40. May 25, 1929.
Timber defects due to fires in 1916 and in 1924-1925 were tallied and measured for a single acre. Figures showed a 15 per cent to 25 per cent loss, or $12. per acre. Computing from the date of the first fire, the loss has been $1. per acre while adequate fire protection could have been provided for 5 cents per acre per year.

372. LODEWICK, J. E. Salvaging fire killed timber. figs. West Coast Lumberman 60(9): 13-14. Sept. 1933.

How degree of fire damage and resultant deterioration may vary even on the same burn.

373. LONG, W. H. Effect of forest fires on standing hardwood timber. Wash., Govt. print. off., 1913. 6p. (U. S. Forest Serv. Circ. 216)

"A discussion of some of the direct and immediate injurious effects of light fires in a forest, based on a study of forest conditions in the Ozark mountains of Arkansas. Special attention is called to the damage to merchantable timber evidenced by fire scars which afford an entrance for destructive worms and rots." - Expt. Sta. Rec. 29(2): 44. July 1913.

374. LUDWIG, W. D. Serious ground fires in southwestern Pennsylvania. Jour. Forestry 21(3): 248-253. March 1923.

"Destructive effects", p. 253: "... the underground fires burned off the roots completely so that it is now possible to pull out the tree, roots and all, without any effort. Where this did not occur the crown and surface fires killed the portion above the ground..."

375. MACLAY, R. D. Fire damage and survival. Service Bul. (U. S. Forest Serv.) 14(23): 5. June 9, 1930.

Results from tagging 100 trees damaged on the Campbell fire in the Olympic National Forest in 1927. The results now are that 60 per cent of the spruce, even lightly burned, and 83 per cent heavily burned, are dead. Of the Douglas fir, none of the lightly burned died, and 32 per cent of the heavily burned have succumbed.

376. MANGIN, L. Contribution à l'étude de la maladie des ronds. Comp. Rend. Acad. Sci. 154: 1525-1528. June 3, 1912.

Prevalent root diseases of conifers in France and Germany due to Rhizina are generally thought to start around fire. The author holds that "it is an error to attribute an influence of any kind to fires." - from review, in Forestry Quart. 11(1): 96-97. Mar. 1913.

377. MEINECKE, E. P. Forest pathology in forest regulation. Wash., Govt. print. off., 1915. 63p. charts. (U. S. Dept. Agr. Bul. 275)

"Fire, then is one of the most important factors in connection with decay; all the more so, as fire generally attacks the butt part of the tree, and decay starting from fire wounds therefore destroys a much greater part of valuable timber than decay in the upper part of the bole." - from p. 49.

378. MEINECKE, E. P. Forest protection--diseases. Jour. Forestry 23(3): 260-267. March 1925.

Summary of the development of forest pathology, and notes on the indirect effects of fire in the forest. Comments by J. S. Boyce follow the paper, p. 268-269.

379. MEINECKE, E. P. Quaking aspen; a study in applied forest pathology. Wash., Govt. print. off., 1929. 34p. illus. "Literature cited": p. 33. (U. S. Dept. Agr. Tech. Bul. 155)

p. 13-16 on effects of fire in decay in aspen. The total cull from decay traceable to fire scars amounts to almost 15 per cent of the total merchantable volume, and represents 68 per cent of the total loss from gross cull.

380. MITCHELL, J. A. Fire damage in mature timber. tables. Proc. Soc. Amer. Foresters 9(2): 239-244. April 1914.

Results of two studies made on the Klamath National Forest six weeks and fourteen months after a severe surface and brush fire. Charts show conditions and amount of damage to yellow pine, sugar pine, and Douglas fir at the end of each period. Article includes also the result of a similar study made on the Shasta National Forest in yellow pine and incense cedar, two weeks and six months after the fire.

381. MUNGER, T. T. Damage by light surface fires in western yellow-pine forests. Proc. Soc. Amer. Foresters 9: 235-238. 1914.

A study made by the U. S. Forest Service to determine (1) how many western yellow pine trees are killed and fire-scarred by an average "light" surface fire in eastern Oregon and (2) how many yellow pine butt logs cut in logging operations are actually damaged. Each surface fire in this region kills outright one merchantable tree to each 2 or 3 acres and leaves 42 per cent of the remaining merchantable trees fire-scarred so that they may fall in the next high wind, or surface fire. Tables show percentage of injury to trees of each diameter class and 5 stages of damage to butt logs.

382. MUNNS, E. N. Fire and the forest. table. Service Bul. (U. S. Forest Serv.) 6(27): 3-4. Sept. 25, 1922.

Damage in a virgin California forest, giving number and species of trees studied, their diameter, and per cent scarred by fire.

383. NELSON, R. M., and Sims, I. H. Fire wounds have close relation to exterior discoloration of bark. U. S. Dept. Agr. Yearbook, 1934. p. 218-220.

A popular account of entry 384, which see.

384. NELSON, R. M., Sims, I. H., and Abell, M. S. Basal fire wounds on some southern Appalachian hardwoods. Jour. Forestry 31(7): 829-837. Nov. 1933.

A study by the Appalachian Forest Experiment Station on oaks and yellow poplars wounded by a spring fire in Virginia. A technic was devised for measuring and recording areas of discolored bark and killed cambium of burned trees. Of the species studied, yellow poplar was most resistant to basal injury from fire, scarlet oak the least resistant, with black, white and chestnut oak intermediate. A short preliminary account of these experiments appears in Forest Worker (U. S. Forest Serv.) May 1932.

385. OSMASTON, A. E. Observations on some effects of fires and on lightning-struck trees in the chir forests of North Garhwal division. Indian Forester 46(3): 125-131. Mar. 1920.

The author disagrees with H. G. Champion (See entry 266) on damage of fire to large trees and resultant insect damage, and believes that no sound tree over 100 feet high will suffer much loss under normal conditions and that trees will not continue to die from fire injury after initial 12 months.

386. RAPRAEGER, E. F. Deterioration of fire-killed Douglas fir. diagr. In U. S. Forest Serv. Pacific Northwest Forest Expt. Sta. Forest Research Note 16, 1935, p. 2.

A summary of results of an investigation undertaken jointly by Section of Products, Div. of Forest Insects and Div. of Forest Pathology. A generalized sketch representing a cross section of a Douglas fir log shows depth of damage in different years after the fire.

387. RAPRAEGER, E. F. Effect of repeated ground fires upon stumpage returns in western white pine. Jour. Forestry 34(7): 715-718. July 1936.

Losses which originated by ground fires are discussed under these headings: (1) understocking and reduced yields (2) decay (3) roughness (totaling $51.75 per acre, or 37 cents per acre per year during the average life of the 141-year-old stand).

388. RODGERS, A. [Correspondence] Ind. Forester 30(8): 372-374. Aug. 1904.

In the forests of lower Burma, notes made from girdled teak trees show that about 60 per cent of the trees have been damaged by fire. These figures may be applied to the whole stand.

389. SALMAN, K. A. Entomological factors affect salvaging of fire-injured trees. Jour. Forestry 32(9): 1016-1019. Dec. 1934. Appears also in Forest Worker (U. S. Forest Serv.) 9(3): 14-15. May 1933.

Results of a 4-year study by Bureau of Entomology on mortality of fire-injured ponderosa pine on a section of the Modoc National Forest, California, after the Sugar Hill fire in 1929. Mortality was greatest during the first and second seasons following the fire, and varied with the amount of foliage injury and, more particularly, with the amount of cambium injury caused by fire. Table shows relative probability of recovery without insect attack.

390. SCHMITZ, Henry, and Jackson, L. W. R. Heart rot of aspen with special reference to forest management in Minnesota. St. Paul, Minn., 1927. 43p. diagrs. (Minn. Agr. Expt. Sta. Tech. Bul. 50)

Fire scars are principal avenues of entrance of Fomes igniarius which is the primary cause of the most important heart rot of aspen in this area.

391. STICKEL, P. W. Forest fire damage studies in the Northeast. II. First-year mortality in burned-over oak stands. "References": p. 598. Jour. Forestry 33(6): 595-598. June 1935.

The need for permitting the burn to "season" before appraising fire damage is especially necessary with trees larger than saplings. This study shows that in two northern oak stands the mortality the first year after burning amounted to 27 and 47 per cent of the number of trees.

392. STICKEL, P. W., and Marco, H. F. Forest fire damage studies in the Northeast. III. Relation between fire injury and fungal infection. "References": p. 423. Jour. Forestry 34(4): 420-423. April 1936.

"Observations on burned-over areas show that in the northeastern forests between 28 and 45 per cent of fire-scarred live trees became infected with fungi, causing decay of the sapwood, within three years after burning." --from introd., p. 420.

393. WOOD. O. M. First year losses after a fire may not represent total mortality. [Philadelphia, Pa., 1936.] 2p. mimeo. (U. S. Forest Serv. Allegheny Forest Expt. Sta. Tech. Note 13)

Comparison of figures after a 1930 New Jersey fire, counts being made in 1930 and in 1932 of 6 species. Notes also the increase of mortality on one plot reexamined in 1936, which showed an increase from 19.0 in 1930 to 34.3 in 1936.

RELATION OF FIRE TO DISEASE AND INSECT ATTACKS

(See also "Direct and Indirect Effect on Merchantable Timber.")

394. BARBEY, Auguste. Après l'incendie (After the fire). illus. Rev. Eaux et Forêts 62(12): 553-560. Dec. 1924.
The ravages of pests in burned areas with special emphasis on Longicornia and Buprestidae.

395. BARBEY, Auguste. La forêt incendiée, champ d'activité des insects (The burned forest, field of activity for insects). Rev. Suisse Zool. 38(3): 393-400. 1931.
Notes on insects attacking a burnt pine forest in Switzerland.

396. BARBEY, Auguste. Incendies et entomologie (Forest fires and entomology). Rev. Eaux et Forêts. 61(5): 145-150. May 1922.
Mainly on the ravages of pests and xylophagous parasites in stands of maritime pine, spreading from the burned sites to adjacent unburned areas.

397. CARTER, E. E. A fire may not be over when it is out. Service Bul. (U. S. Forest Serv.) 13(26): 3. July 1, 1929.
A summary of the U. S. Bureau of Entomology's findings on a Western pine beetle epidemic following a fire on the Sierra National Forest in 1924, indicating that the infestation which builds up on a burn in fire-weakened trees is short-lived.

398. DEARNESS, John, and Hansbrough, J. R. Cytospora infection following fire injury in western British Columbia. "References": p. 128. Canad. Jour. Research 10(1): 125-128. Jan. 1934.
Data are given concerning the appearance of Cytospora spp. on 15 species of shrubs and trees following a light ground fire near D'Arcy, B. C. in 1931.

399. DODGE, C. R. Insects vs. fires. illus. Sci. Amer. suppl. 69(1777): 61-62. Jan. 22, 1910.
A popular account of work done by A. D. Hopkins, U. S. Bureau of Entomology, on destruction of mature and young forest growth by insects, and the relationship of insects and fire.

400. GRAHAM, S. A. Some entomological aspects of the slash disposal problem. Jour. Forestry 20(5): 437-447. May 1922.
Slash disposal by burning is not as effective in controlling injurious insects as many foresters believe, is

this entomologist's conclusion after a study from 1920-1922 on burned and unburned slash in Itaska Park, Minnesota.

401. JAENICKE, A. J. Relation between fires and insect damage. Timberman 22(3): 113, 116. Jan. 1921.

"Intensive and carefully conducted experiments by the Bureau of Entomology in Washington, Oregon, as well as careful observations by this bureau in California and other parts of the Pacific Coast and the Inland Empire indicate that insect infestation may be increased as much as 1,000 per cent after even these light fires which are advocated by the advocates of light burning practice. These losses occur primarily in timber which has been scorched, but fortunately, these increases are temporary in nature and within a period of two or three years at the most, the insect infestation is again what it was before the advent of fire." - from p. 116.

402. KEEN, F. P. Barkbeetles pick fire-retarded pines. Forest Worker (U. S. Forest Serv.) Nov. 1926. p. 41-43.

Cores from live trees in a burned area on the Modoc National Forest showed that their growth had been retarded in about the proportion that their leaf surface had been destroyed by fire and that barkbeetles showed a preference for these retarded trees.

403. MENON, C. K. Does fire, or exposure of trees growing under shade, or damage to hosts lead to spike disease in sandal? Indian Forester 45(9): 498-500, Sept. 1919.

The author believes that injury by fire will not lead to spike in sandal where spike does not already exist on the species.

403a. MILLER, J. M., and Patterson, J. E. Preliminary studies on the relation of fire injury to bark-beetle attack in western yellow pine. illus. Jour. Agr. Research 34(7): 597-613. Apr. 1, 1927.

"Conditions on burned areas in southern Oregon and northern California, including the Mistletoe Burn of 800 acres were studied. Forest fires of sufficient severity to scorch the bark, cambium and foliage of yellow pines make certain trees especially attractive to the western pine beetle. The attraction of fire-injured trees for a distance of 2-3 miles often causes a concentration of beetles within a burned area, but this concentration does not become epidemic. Fires not severe enough to burn the bark from the infested trees are of little value in controlling infestations. Trees defoliated by fire may present an abnormally moist condition of the inner bark resulting in high mortality of early larval stages.

The principal rôle of barkbeetles in connection with forest fires is in the added destruction by the insects of moderately fire-injured trees which would otherwise have survived. - J. M. Miller, in Biol. Abs. 2(1/2): 222. Jan./Feb. 1928.

404. MILLER, J. M. Why the western pine beetle follows fire. Forest Worker (U. S. Forest Serv.) 5(4): 16-17. July 1929.

A study by U. S. Bureau of Entomology on the Northfield burn (1924) on the Sierra National Forest, California, which revealed that the degree to which this barkbeetle concentrated in burns of the western yellow pine type depends upon the quantity of defoliated or partially defoliated timber that survives the initial fire injury.

405. [NESTERCHUK, G. I.] [Forests of Karelia-Murman and their pests.] Bolezni Rastenii 19(3/4): 159-182. 1930.

In Russian, with German summary. "Among the chief causes contributing to the development of pests in the region are forest fires and cutting in the forest without proper disposal of slash..." - From Biol. Abs. 6(3): 675. March 1932.

406. POVAH, A. H. W. An attack of poplar canker following fire injury. illus. "Literature cited": p. 165. Phytopathology 11(4): 157-165. April 1921.

A study of a burned area near Syracuse, New York, which appeared to have been damaged very little. The disease extended only in the burned areas, and neighborind trees were not infected unless they were in the path of the fire. In the diseased area over 68 per cent of poplars were infected and over 30 per cent killed. Populus grandidentata is a new host for this pathogen.

407. ST. GEORGE, R. A. Insects as indicators of fire injury. Forest Worker (U. S. Forest Serv.) 4(5): 15. Sept. 1928.

Entomologists can predict with a considerable degree of certainty the per cent of mortality of fire-injured trees by studying the attack of certain insects after the fire. This can be done many months earlier than by any other method.

408. STEBBING, E. P. The effect of forest fires on insect pests. Indian Forester 29(2): 75-80. Feb. 1903.

This writer feels that fires may have a good or bad effect on insects. In the sal forest fires may check insects by destroying them or their food but at the same time a retardation in increment occurs. In the coniferous forests, fires are followed by severe attacks of

bark borers. Without further investigation it is impossible to estimate the good or bad effect of forest fires.

409. STICKEL, P. W. Forest fire damage studies in the Northeast. I. Bark beetles and fire damaged hardwoods. "References": p. 703. Jour. Forestry 32(7): 701-703. Oct. 1934.
Studies showing the close relationship between degrees of fire injury and bark beetles. More than one inspection is necessary to determine accurate damage appraisals.

410. STRATONOVICH, A. I. Usykhanie sosny v razlichnykh tipakh lesa posle pozhara 1920-1921 g. v Kurshinskom lesnichestze kiazanskoi gub (The drying up of pine in forests of different types after the 1920-1921 fire in the Kurshinsk forest in the province of Riazan). Sbornik Rabot Naychnykh Kruzhkov Leningradskogo Lesnogo Inst., p. 3-24. 1928.
In Russian. Fire injury to bark, and the relation of fire to certain insect pests. Abstracted by V. Rimsky-Korsalsoff, in Biol. Abs. 8(6): 1550. June/July 1934.

411. SWAINE, J. M. Insect armies that follow in the wake of fire. Illus. Canad. Forestry Mag. 18(3): 666. Mar. 1922.
Barkbeetles and how they operate on fire-weakened standing timber.

412. VERRALL, A. F. The dissemination of Septoria acicola and the effect of grass fires on it in pine needles. Phytopathology 26(10): 1021-1024. Oct. 1936.
Temperatures that kill leaf tissue also kill the Septoria in that tissue.

413. WEIR, J. R. The effect of broadcast burning of sales areas on the growth of cull-producing fungi. Jour. Forestry 21(2): 183-184. Feb. 1923.
Lists the most important cull-producing fungi, the species of tree and kind of slash they inhabit and the result 3 or 4 years after the fire, and concludes that in some cases broadcast burning in the white pine belt may be considered good silviculture.

414. WHITE, S. E. The tree killing beetles of California. Amer. Lumberman (2181): 32-33. March 3, 1917.
The author takes issue with the Bureau of Entomology and the Forest Service on control measures against insects, and holds that insects do not attack fire-weakened trees more than they do sound ones.

415. WHITE, S. E. The tree killing beetles of California and possible remedies. Amer. Lumberman (2169): 30-31. Dec. 9, 1916.
Advocates light burning to curb insects and to protect the forest from devastating, uncontrollable fires.

EFFECT ON SOIL-WATER RELATIONSHIPS

(See also entries 16, 63, 65, 124, 160, 162, 171, 178, 185, 192, 194, 197, 199, 200, 220, 228, 231, 238, 243, 250, 252-254, 264, 296, 297, 503, 516.)

416. BENNETT, H. H. Relation of erosion to vegetative changes. illus. Sci. Mo. Nov. 1932, p. 385-415.

Includes data on run-off and erosion on two plots in post-oak timber, one on which the forest litter was burned and an adjacent one on which the litter was undisturbed. Run-off on unburned area: 250 gallons per acre; on burned area: 27,600 gallons. Soil eroded from unburned area: 0.01 ton per acre per year; on the burned area, 0.15 ton per acre per year.

417. CONNAUGHTON, C. A. Forest fires and accelerated erosion. chart. Jour. Forestry 33(8): 751-752. Aug. 1935. Digested in Service Bul. (U. S. Forest Serv.) 19(10): 1-2. May 13, 1935.

Results of a study in the ponderosa pine forests of Idaho, in which it was found that accelerated erosion occurred after fire on 42 per cent of the plots established on cut-over land, and on 28 per cent of the plots on virgin forest land. It was found that there was little difference in amount of erosion on areas burned over by a crown fire or by a severe surface fire on cut-over land.

418. COVENTRY, B. O. Denudation of the Punjab hills. illus. Indian Forest Rec. (Silviculture ser.) 14(2): 49-78. 1929.

p. 14-16 is on fire as a cause of denudation and its results in different forest zones. Discussion of light burning rather than accidental fires. Certain species are replaced by "colonisation forests", which show increasingly poor resistance to fire damage.

419. DANA, S. T. Farms, forests and erosion. illus. U. S. Dept. Agr. Yearbook, 1916, p. 107-134. Appears also in Canad. Forestry Jour. 13(3): 1009-1013. March 1917.

Includes, on p. 110-113, the influence of fire on erosion, with excellent explanatory photographs.

420. EATON, E. C. Relation of fires to water conservation in Los Angeles county. Jour. Forestry 30(5): 605-607. May 1932. Apears also in Serv. Bul. (U. S. Forest Serv.) 16(39): 2-5. Dec. 5, 1932.

The Chief Engineer, Los Angeles County Flood Control District, shows how fire, by removing the vegetative cover of watersheds, is a destructive enemy of water conservationists.

421. GRASS burning and erosion. Farm. South Africa 5(60): 570. March 1931.

An engineer from the Potchefstroom School of Agriculture is cited in this article as observing several destructive results of grass burning.

422. KRAEBEL, C. J., and Kellogg, L. F. The forest guardians of our watersheds. Jour. Forestry 36(9): 858-860. Sept. 1938.

A digest of Forest Service research on soil and water relationships, noting experiments in which fire was a factor in watershed deterioration.

423. KRAEBEL, C. J. Influence of vegetation on runoff and erosion. Service Bul. (U. S. Forest Serv.) 19(21): 5-6. Oct. 14, 1935.

Results of experiments on areas burned once, areas burned annually for 5 years and comparable unburned areas at the California Forest and Range Experiment Station.

424. LOWDERMILK, W. C. Influence of forest litter on run-off, percolation, and erosion. illus. Jour. Forestry 28(4): 474-491. Apr. 1930.

"Both natural and artificial rainfall, surficial run-off, percolated water, and eroded material were measured on 4 chaparral-covered plots in southern California and at Berkeley, Calif., in eight 2 x 5 ft. tanks containing reconstructed profiles of Aiken, Holland, and Altamont soils, with natural litter on top. Alternate chaparral plots were burned over, and the litter on alternate tanks was burned off. Forest litter, even after it was saturated, greatly reduced surficial run-off, especially in fine-textured soils. Destruction of the litter increased erosion even more than it did run-off, and reduced the absorption rate of the soil..." - P. C. Wakeley, in Biol. Abs. 5(4): 1161. Apr. 1931.

425. MEGINNIS, H. G. Effect of cover on surface run-off and erosion in the loessial uplands of Mississippi. "Literature cited": p. 14-15. Wash., Govt. print. off., 1935. 15p. illus. (U. S. Dept. Agr. Circ. 347)

426. MEGINNIS, H. G. The Yazoo flood and its causes. illus. Amer. Forests 38(11): 592-593, 623-624. Nov. 1932.

A less technical paper than the preceding entry, on heavy run-off from burned areas, and slow run-off from similar unburned areas.

427. MUNNS, E. N. Chaparral cover, run-off, and erosion. Jour. Forestry 18(8): 806-814. Dec. 1920.

Results of a study made in the San Dimas, Pacoima, Little Tejunga and Dalton canyons in the Angeles National Forest, California, after a fire occurred. The effect of fire upon chaparral cover and, in turn, the effect of destruction of chaparral cover on streamflow and erosion is stated. p. 814 gives list of seeds which escaped fire and erosion.

428. MUNNS, E. N. Erosion and flood problems in California. In Rept... on Senate concurrent resolution no. 27 (Legislature of 1921) by the California State board of forestry. Sacramento, Calif., State print., 1923. 165p. illus. Also appears in U. S. Cong., 70th, 1st sess. Hearings before the committee on flood control, House of representatives. pt. 5. Wash., Govt. print. off., 1928, p. 3242-3263.

Includes fire as an agency promoting erosion, with a discussion of the effects of fire, both chemical and physical, on soils. Bibliography, p. 123-143.

429. MUNNS, E. N., and Sims, I. H. Forests in flood control; supplemental report to the Committee on flood control... 74th Cong., 2nd sess. on H. R. 12517. Wash., Govt. print. off., 1936. 70p. tables.

Consequences of disturbing the forest cover: Fire, p. 20-24 summarizes the findings of research workers in this field, covering effects of fire on run-off and floods for different sections of the country.

430. STEWARD, A. N. The burning of vegetation on mountain land, and slope cultivation in Ling Yuin Hsien, Kwangsi province, China. Lingnan Sci. Jour. 13(1): 1-3. Jan. 1934.

Farmers in this remote region of China habitually burn their slopes during the dry season, thus perpetuating coarse perennial grasses and turning most of the richly forested country into hilly grassland. The author concludes from his field observations that since neither the original evergreen forest nor the band of trees and shrubs along the streams burn freely, that woody vegetation cover conserves moisture. It is not merely the cutting and burning over of an area, but the resultant breakdown of the forest soil and its water-holding capacity that is destructive. Eleven photographs illustrate the article.

431. STEWARD, A. N., and Shu-Yuen, Cheo. Geographical and ecological notes on botanical explorations in Kwangsi province, China. illus. Nanking Jour. 5(1): 173-195. May 1935.

Gives reasons why the natives of this region burn the

slopes. The author believes that such burning affects streamflow, and he shows that the character of the vegetation is changed by annual fires.

432. THOMPSON, M. W. Erosion in the Black Hills after the burning of the forest cover. illus. U. S. Dept. Agr. Yearbook, 1935, p. 181-184.

Erosion following a burn near Rockford contrasted with no erosion on an adjacent area which was not burned.

433. U. S. FOREST SERVICE. A national plan for American forestry... in response to S. Res. 175, 72d Cong. Wash., Govt. print. off., 1933. 2 vol. (U. S. 73d Cong. 1st sess. Senate Doc. 12)

"Consequences of disturbing the forest cover: Fire", p. 316-320, by E. N. Munns and others, covers the damaging effects of fire and the resultant increase in erosion and floods. Includes references to outstanding published papers on the subject. Additional sections on effect of fire on watersheds appear on p. 408-409 and 456. The effect of fire on hardwood and softwood growth, reproduction, decay and sprouting, by R. M. Evans, p. 857-861. Table showing fire-killed standing timber in the 8 regions of the U. S. appears on p. 218.

EFFECT ON NAVAL STORES

(See also entries 56, 266, 307, 520.)

434. BAKER, H. L. Fire in the turpentine orchard. In Pine institute of America. Pine tree chemical industries yearbook, 1929, p. 55-57.

Figures cited showing that longleaf trees grow 80 per cent faster in diameter on unburned land than on burned, and a reference to N. G. T. Simerly's belief that there is 25 to 33 per cent greater gum yield where fire has not occurred. A discussion of cost of fire protection and effectiveness of industrial companies in Louisiana and Georgia.

435. BAKER, H. L. Gum yields on burned and unburned land. Forest Worker (U. S. Forest Serv.) 3(5): 14. Sept. 1927.

Based upon casual observations, N. G. T. Simerly, manager of the woodlands of Tennessee Coal and Iron co., Stapleton, Ala., is of the opinion that light burning prevents maximum yields in gum.

436. CARY, Austin. How the yield of gum is affected by scorching of trees. Naval Stores Rev. 37(49): 26. March 3, 1928.
Observations on the effect of a light fire in South Carolina which ran through a longleaf forest just previous to hanging cups. It was clear that burning decreased the yield of gum, in some cases up to one-third of capacity.

437. CARY, Austin. Studies on flow of gum in relation to profit in naval stores industry; 33rd paper. Naval Stores Rev. 39(11): 14, 16. June 15, 1929.
The effect of scorching of trees on the yield of gum.

438. CARY, Austin. Studies on flow of gum in relation to the naval stores industry; 35th paper. Naval Stores Rev. 40(45): 23, 25. Feb. 7, 1931.
Final report on tests dealing with the effect of fire on yield of gum which was begun in 1927. Conclusions are noted on yield of gum, mortality, and diameter growth for first and second year following the burning.

439. CARY, Austin. Studies on flow of gum in relation to profit in the naval stores industry; 43d paper. Naval Stores Rev. 42(3): 14-15. Apr. 16, 1932.
Includes a table showing yield of gum from scorched and unburnt trees from March 30 to October 19, 1931.

440. CARY, Austin. Studies on flow of gum in relation to profit in the naval stores industry; 46th paper. Naval Stores Rev. 42(8): 14-15. May 21, 1932.
Three paragraphs on harm that repeated burning does to rate of growth of longleaf pine.

441. CARY, Austin. Studies in flow of gum in relation to profit in the naval stores industry; a condensed account of experiments conducted from 1920 to 1931, 2d installment. Naval Stores Rev. 43(17): 6, 8, 17. July 22, 1933.
This second installment of summary of experiments included fire and its effects on gum yield, diameter and height growth.

442. ELDREDGE, I. F. Fire problem on the Florida national forest. Proc. Soc. Amer. Foresters 6: 166-170. 1911.
Gives advantages and disadvantages of complete fire protection in the turpentining areas of Florida.

443. GERRY, Eloise. Oleoresin production from longleaf pine defoliated by fire. illus. "Literature cited": p. 836. Jour. Agr. Research 43(9): 827-836. Nov. 1, 1931.
Field observations and laboratory tests on the effects of scorching foliage on tree vitality and growth and effects of scorching on internal structure. If scorched

trees survive, after three years they may yield practically as much oleoresin as unscorched trees and also are able to make an appreciable gain in wood growth. The recuperative power of longleaf pine from fire injury is strikingly illustrated.

444. GERRY, Eloise. Wood and oleoresin formation in turpentined longleaf pine as affected by spring forest fire. Amer. Jour. Bot. 14(10): 621. 1927.
A physiological study. Noted in Biol. Abstracts 3(4/6): 480. Apr./June 1929.

445. LIGHT burning the piney woods meant cost of $30. an acre. Naval Stores Rev. 35(39): 19. Dec. 26, 1925.
The Southern Forest Experiment Station describes what an annual grass or ground fire can do to a turpentined stand of old-growth longleaf pine timber.

446. U. S. FOREST SERVICE. Southern forest experiment station. Burned faces and subsequent turpentining. In its Southern forestry note 21, 1938, p. [2].
A study made on second-growth longleaf and slash pine following a fire after which turpentining operations had been suspended for two years, to determine the factors associated with the optimum height of jump-streak and the percentage of dry-face.

447. U. S. FOREST SERVICE. Southern forest experiment station. Effect on gum yield of defoliation by fire. In its Southern forestry note 18, 1937. p. [1].
An experiment begun in 1933 showed that gum-yielding capacity of longleaf pine, burned in March, declined rapidly until June, and recovered to about normal in November. Decrease in gum-yield is roughly proportional to amount of defoliation.

EFFECT ON RECREATION AND WILDLIFE

448. CLARK, H. W. Fire and bird populations. Condor 37(1): 16-18. 1935.

"Forest fire, Aug. 31, in Napa county, Calif., denuded some areas completely, killed but did not burn trees in others, left a few firs and manzanitas in sheltered places and the alders in the bottom of Bell's Canyon unharmed. In the summer of 1932 an increased number of birds of several spp. was noted in the regions bordering the burned area, but in 1933 and 1934 these birds were back to their original status. Although there were few birds in the burned area from the time of the fire through 1932, in 1934 about the same grouping of birds was seen and heard as before the fire, and the vegetation was heavy but lacking in manzanitas and conifers." - F. Hague, in Biol. Abs. 9(9): 1946. Nov. 1935.

449. CLEPPER, H. E. Forest fires and game supply. Pa. Dept. Forests and Waters. Serv. Letter 6(9): [1-3]. Feb. 28, 1935.

After a fire the chemical substances in ashes combine with water in the soil and form saline compounds which are taken up as food by plants. These are palatable to deer. But these salts are leached out of the soil in a few years. Fires do bring about favorable food supplies for deer. Balanced again this one temporary good, the author mentions 13 evils of fires, including destruction to soil, reproduction and game.

450. CONWAY, R. C. Marsh burning. Wisc. Conserv. Bul. 3(7): 9-10. July 1938.

Predominately on destruction of bird cover, by fire.

451. COOPERATIVE quail study association. Annual report, 1st-6th. 1931/32-1936/37. Thomasville, Ga., 1932-38.

These reports contain sections on use of fire in quail management, and also destructive use of fire.

452. CURWOOD, J. O. Wild life and wildfire. illus. Amer. Forestry 29(351): 140-144, 177. Mar. 1923.

A novelist's conception of the effects of fire upon the extermination of certain game animals and the decimation of the numbers of others.

453. DANA, S. T. Forest fires and recreation. illus. Amer. Forests 32(393): 515-520. Sept. 1926.

The relation of recreationists' camp fires to forest devastation, and the effect fires have on subsequent recreation travel and scenic beauty.

454. FOREST fires menace the fur trade. Fur Trade Rev. 51(8): 80-81, 100. May 1924.
In Canada, Alaska and northern United States.

455. FOREST fires, the plague of the fur trade. illus. Illus. Canad. Forestry Mag. 18(2): 603-604. Feb. 1922.
On the disastrous effect of fire on wildlife.

456. GABRIELSON, I. N. Forest fire and wildlife. Four L Lumber News 10(13): 32. May 1928.
The toll of wild life by forest fires.

457. GUTHRIE, J. D. Fire in the sanctuary. illus. Outdoor America 7(1): 5-7, 29, 42. Aug. 1928.
Popular article on the destruction of wildlife by forest fires.

458. HICKEL, M. R. Don't burn up the game. Service Bul. (U. S. Forest Serv.) 16(10): 5. Mar. 7, 1932.
A warning (against spring burning of fields because of the resultant destruction to game birds) which is enclosed with every box of shot gun shells sold by Gamble Stores.

459. KIPP, D. H. Wild life in a fire. illus. Amer. Forests 37(6): 323-325, 360. June 1931. Appears also in Sci. Amer. 145(3): 158-159. Sept. 1931.
The Wisconsin Conservation Commission's survey on game killed by a fire. Illustrated by excellent photographs showing destruction.

460. LEOPOLD, Aldo. Fires and game. Jour. Forestry 24(6): 726-728. Oct. 1926.
Grass fires as an agency in destroying game and song birds, and the Izaak Walton League's protest.

461. LEOPOLD, Aldo. Wild followers of the forest; the effect of forest fires on game and fish--the relation of forests to game conservation. illus. Amer. Forests 29(357): 515-519, 568. Sept. 1923.
Illustrated by photographs by the U. S. Forest Service.

462. PIMLEY, A. F. Game and forest fires. Fins, Feathers and Fur 91: 7, 15, 1930.
Destruction of wildlife by fire, and economic results.

463. STANLEY, T. L. Effect of forest fires on tourist travel. chart. Jour. Forestry 30(5): 608-615. May 1932.
A report from California showing that fires, aside from completely destroying recreation grounds, cause money loss to towns near forest recreation centers.

464. STODDARD, H. L. The use and abuse of fire. In his The bob-white quail. N. Y., Charles Scribner's sons, 1931. 559p.
Chapter 15 covers the harmful effect of fire on game cover, and also the use of fire in intelligent wildlife management.

465. STODDARD, H. L. Use of controlled fire in southeastern upland game management. Jour. Forestry 33(3): 346-351. March 1935.
Controlled burning is recommended on land where quail and wild turkey are of first importance, and on the open pineland type of forest. The season, frequency of burning and caution are discussed in relation to burning to improve food and cover conditions for wildlife, and to control pests and diseases.

466. URNER, C. A. Effect of fires on pine barren bird life. Auk 43(4): 558-559. 1926.
"Effect of fires in late winter and early spring on New Jersey pine barrens was less marked than anticipated on the breeding birds the ensuing summer. Toxostoma rufum and Pysilo erythrophthalmus somewhat concentrated in the unburned area about the fire district; the distribution of Dendroica vigorsi and D. discolor was little affected; Chordeiles virginianus had come to nest where the areas were burned quite clear." - J. T. Nichols, in Biol. Abs. 2(1/2): 25. Jan./Feb. 1928.

FIRE-RESISTANCE OF TREES

467. FLINT, H. R. Characteristics influencing fire resistance of northern Rocky mountain conifers. Forest Worker (U. S. Forest Serv.) Sept. 1925, p. 22-23.
Remarks on experiments in this field, mentioning J. V. Hofmann and Heinrich Mayer, who reported that cambium in trees is killed when heated to 129°F. The author notes that the intolerant trees of this region are highly fire-resistant, the tolerant ones susceptible to fire injury.

468. FLINT, H. R. Fire resistance of northern Rocky mountain conifers. Missoula, Mont., 1925. [5]p. table. (U. S. Forest Serv. Northern Rocky Mountain Forest Expt. Sta. Appl. Forestry Note 61)
Eleven silviculturally important conifers of this region, their relative fire-resistance and the characteristics that make them fire-resistant.

469. GISBORNE, H. T. Fire damage and degree of protection. Service Bul. (U. S. Forest Serv.) 14(30): 4. July 28, 1930.
Comparison of measurements of degrees of fire-resistance of certain western tree species.

470. HEPTING, G. H., and Blaisdell, D. J. A protective zone in red gum fire scars. illus. Phytopathology 26(1): 62-67. Jan. 1936.

Among 7 tree species studied in the Mississippi Delta, red gum and persimmon were the most resistant to decay infection through fire scars. Hackberry and nuttall oak were the most susceptible. The article is primarily on an analysis of the red gum's protective zone formed in its fire scar which may remain as an effective seal from further harm for many years.

471. LACHMUND, H. G. Relative susceptibility of incense cedar and yellow pine to bole injury in forest fires. Jour. Forestry 21(8): 815-817. Dec. 1923.

Incense cedar suffers much heavier injury from fire than western yellow pine, due to structure, composition of wood and bark, and because insects infest the fire-injured incense cedar and destroy living cambium bordering the injury, and enlarge the fire scar.

472. RADCLIFFE, F. The susceptibility of silver fir (Abies webbiana) to damage from fire. Indian Forester 29(8): 339. Aug. 1903.

Why this is the least fire-resistant of all the common conifers of the Himalayas.

473. SIMS, I. H. Specific differences in basal wounding by fire of southern Appalachian hardwood trees. Jour. Elisha Mitchell. Sci. Soc. 48: 17. Oct. 1932. (abstract)

474. STARKER, T. J. Fire resistance in the forest. tables. "References": p. 467. Jour. Forestry 32(4): 462-467. Apr. 1934.

Rates forest trees of various regions in order of their degree of resistance to fire, which is a factor to be considered in reestablishing forests.

475. STARKER, T. J. Fire resistance of trees of northeast United States. Forest Worker (U. S. Forest Serv.) 8(3): 8-9. May 1932.

Compilation of opinions of 41 foresters on relative fire resistance of 22 tree species based on bark thickness, root habit, branch habit, canopy cover and degree of imflammability of foliage.

476. WEBBER, H. J. The Florida scrub, a fire-fighting association. "Literature cited": p. 360-361. Amer. Jour. Bot. 22(3): 344-361. March 1935.

The Florida scrub acts as a fire-break because: (1) The sparce succulent evergreen foliage sheds gradually, permitting disintegration without accumulation.

(2) Bareness of the soil covering. (3) Bareness of the soil on the margins. Due to lumbering operations scrub fire-break margins are becoming overgrown with grasses and scrub fires are increasing.

FIRE DAMAGE APPRAISAL

(See also entries 64, 391, 392, 393.)

477. BENTLEY, B. H. Fire damage to old stands in northern Tennesee. Jour. Forestry 36(6): 610-611. June 1938.

A corporation deducting from its income tax 61 cents per acre as loss of mature timber due to forest fires, was questioned by the Bureau of Internal Revenue. An appraisal was made. This article describes factors considered and estimated loss to old timber by fire.

478. CLARK, F. G. Appraisal of fire damage to immature timbers for statistical purposes. Jour. Forestry 17(1): 36-38. Jan. 1919.

"The author here proposes a modified replacement formula, which it is believed will overcome certain difficulties met with in the use of straight expectation or replacement methods of appraising fire damage to immature timber." - Expt. Sta. Rec. 40(9): 843. June 1919.

479. McCARTHY, E. F. Analysis of fire damage in southern Appalachian forests. illus. Jour. Forestry 26(1): 57-68. Jan. 1928.

Pointsin appraising fire damage gathered from data on a burned area of the Pisgah National Forest. Discusses factors to be determined only after one growing season following the fire. Includes loss of soil fertility, loss from insects and decay, and variations of damage according to type and age classes.

480. McDANIELS, E. H. Forest fire damage appraisal. Jour. Forestry 29(7): 1034-1041. Nov. 1931.

A method of fire damage appraisal in immature stands recommended for use in Oregon and Washington.

481. RHODE ISLAND. Commissioner of forestry. Damage by fire [by J. B. Mowry]. Providence, R. I., 1911. 3p. (Leaflet 4)

Crown, surface and ground fires--their injurious effects and how to estimate damage to mature woods entirely killed and partly killed, and immature timber entirely killed and partly killed.

482. ROGERS, Robert, and Moore, Barrington. A method of assessing fire damages in the Southwest. Forestry Quart. 9(3): 412-419. Sept. 1911.

"This consists of a detailed statement of a suggested method for finding the value of forest products destroyed by fire in the Southwest." - Expt. Sta. Rec. 25(8): 843. Dec. 1911.

483. U. S. FOREST SERVICE. Standard instructions for the determination of fire damages. [Wash., D. C., 1914]. 14p. mimeo.

How to appraise fire damage in mature and immature timber, and damage to forage, with examples.

484. U. S. FOREST SERVICE. Lake states forest experiment station. Estimating fire damage in the Lake states. St. Paul, Minn., 1934. 1p. mimeo. (Tech. Note 75)

Table showing relative value per acre of second growth stands of 7 forest types based on average merchantable value discounted to the average age of the size classes represented.

485. U. S. FOREST SERVICE. Lake states forest experiment station. Fire damage as affected by season of burning. St. Paul, Minn., 1933. 1p. mimeo. (Tech. Note 58) Appears also in Serv. Bul. (U. S. Forest Serv.) 17(16): 4. July 31, 1933.

In open stand of all-aged jack pine. Results show that spring fires are particularly destructive to seedlings and saplings but do little damage to merchantable timber. Summer fires are less destructive to small trees but do considerable damage to larger trees.

486. U. S. FOREST SERVICE. Lake states forest experiment station. How soon after a fire can damage be determined? St. Paul, Minn., 1933. 1p. mimeo. (Tech. Note. 57)

In jack pine, 3 or 4 months should be allowed to elapse before damage estimates are made.

LIGHT OR CONTROLLED BURNING

General

(See also entries 32, 41, 45, 49, 56, 87, 233, 250, 252, 260, 265, 301, 318, 319, 330, 338, 340, 341, 418, 451, 464, 465.)

487. CHANNER, F. F. R. Annual progress report of forest administration in the United Provinces [India] for the year 1928-29. Allahabad, Supt. Govt. press, 1929. 35p.
Includes an account of an extended study of controlled burning as an aid to regeneration and as a protective measure. Reports for other years continue the results.

488. DAWKINS, C. G. E. Early burning in young regeneration areas. Rangoon, Supt. Govt. print., Burma, 1921. 6p. (Burma. Forest Bul. 2)
Experiments of controlled burning in India, mostly in stands of teak. Introduction to the bulletin by H. R. Blanford emphasizes the complexity of early controlled burning and its silvicultural application.

489. DUTTA MAL, Guran. Fire protection and the natural regeneration of deodar in the forests of the Kulu division, Punjab. Indian Forester 32(5): 245-247. May 1906.
Twenty years after the Punjab Forest Department divided its holdings into protected areas and "phats", to be burned by the natives under the control of the Forest Department, slopes which were bare at the time of demarcation was in 1906 densely covered with deodar and kail. Article gives advantages and disadvantages of "phat" burning in this section of India.

490. FIRE - master or servant. Amer. Forests 37(10): 605. Oct. 1931.
This article discusses various views on annual burning.

491. HEIKINHEIMO, Olli. Kaskiviljelyksen vaikutus Suomen metsiin (The influence of controlled clearing by fire on Finland's forests). illus. Acta Forestalia Fennica 4(2): 1-264. 1915.
Article is followed by 149 pages of tables and a 59-page summary in German, each paged separately. Includes brief description of burning methods used in Germany, Russia, Sweden and other European countries. Other chapter headings are: Frequency of application of firing method in Finland; Methods; Firing regulations; Influence of burning on quality of the forests; Reforestation of fire-denuded areas by (a) seeding, (b) sprouting; Burning and forage value of woodland areas; Types of

fired woodlands and their development; Influence of fire-management upon the abundance of forests; Influence of firing on occurrence and distribution of forests. Typewritten translation of summary of the article is in the U. S. Forest Service Library.

492. KESSELL, S. L. Use of fire in sylviculture. Aust. Forestry Jour. 10(8): 206-207. Aug. 15, 1927.
The Conservator of Forests in Western Australia comments on article on fire by R. Unwin (See entry 499) with special reference to its use in the silvicultural management of jarrah, a eucalypt.

493. MILROY, A. J. W. The relation between sal forests and fire. Indian Forester 56(10): 442-447. Oct. 1930.
Article gives directions for burning in order to return the forest to its original open grassy state which encourages sal natural reproduction, and at the same time to reduce the adverse effect of fire upon growing trees as much as possible.

494. MORAVETS, F. L. Second growth Douglas fir follows cessation of Indian fires. Service Bul. (U. S. Forest Serv.) 16(20): 3. May 16, 1932.
Whidby Island, once largely deforested by repeated light burning, is now well forested by Douglas fir.

495. SOCIETY OF AMERICAN FORESTERS. Ozark section. Resolutions of the Ozark section [on controlled burning]. Jour. Forestry 33(4): 437-438. April 1935.
Five resolutions concerning publications and publicity of controlled burning which, even in longleaf pine lands, should not be given formal status until foresters as a whole of an affected region are convinced of its practicability, and results are final and conclusive.

495a. SPAULDING, Perley. References to literature on slash disposal. Amherst, Mass., Office of forest pathology, Bureau of plant industry, 1925. 16p. mimeo.
List of annotated references dealing especially with Northeastern conditions. Includes disposal of brush and slash by burning, and its effect on protection and reproduction.

496. TROUP, R. S. Pinus longifolia, a silvicultural study. Calcutta, Supt. Govt. print., 1916. 126p. illus. (Indian forest memoirs (Silviculture ser. 1, pt. 1.)
Chapter six (p. 67-78) is on fire, which is the greatest danger to which chir forests are exposed. Summary of research done on fire-damage and benefits with the result that regular burning is done on all except regeneration areas, which are under strict fire protection.

497. U. S. FOREST SERVICE. Federal policy relating to controlled burning in longleaf pine region. Forest Worker (U. S. Forest Serv.) 8(4): 7-9. July 1932.

Comprehensive summary of the U. S. Forest Service policy on controlled burning for silvicultural purposes and for fire protection; issued primarily for cooperating State Forestry Departments under section 2 of the Clarke-McNary act.

498. U. S. FOREST SERVICE. Southern forest experiment station. Controlled burning after thinning. In its Southern Forestry Notes, 19, 1937. p. [2].

Results of two years of study on effect of burning and thinning six- to eight-year-old slash pine showed that for each stand type--open, dense and very dense--the relative height growths were about the same, regardless of burning.

499. UNWIN, R. The use of fire in silviculture. Australian Forestry Jour. 10(4): 87-88. Apr. 15, 1927. Abstracted by C. F. Korstian in Biol. Abs. 2(1/2): 264. Jan./Feb. 1928.

Article by the Professor of Forestry, University of Rangoon, on the beneficial use of light burning in teak forests. Teak, in common with other trees, puts on better increment without fire but protection upsets the balance of nature and in moist forests, teak forest began to become evergreen in character and in other areas bamboos and evergreen oaks invaded so that teak had little chance of regenerating. Management plans now include rather severe burning. When the young crop has been obtained, fire is excluded for at least ten years. Beneficial results of burning is not due entirely to the effect of mineral fertilizers from the ash, but is due also to bacterial action which is more active after a fire because heat kills more amoeba than bacteria. Bacteria therefore after a fire increase more rapidly than the enemies, Amoebae, and for a time nitrates and ammonia are formed more rapidly, with beneficial results to plant growth. The author also notes that the soil for germination of eucalypts at Ootacamund, India, is first roasted until every trace of humus is destroyed before use in nursery beds, and is very successful. See entry 492 for note on the article by S. L. Kessell.

500. WAHLENBERG, W. G. Fire in longleaf pine forests. New Orleans, La., 1935. 4p. (U. S. Forest Serv. Southern Forest Expt. Sta. Occasional Paper 40). "References": p. 4.

A concise statement of opinion of research men at the Southern Forest Experiment Station on the use of

controlled burning as a supplementary aid in the silviculture, management and protection of longleaf pine forests, extracted from the Station's 12th annual report. 1933, p. 7-10.

501. WHEELER, H. N. Controlled burning? Service Bul. (U. S. Forest Serv.) 19(23): 4-6. Nov. 11, 1935.
The author deplores light burning "propaganda" and urges that data be accumulated for 25 years before a definite statement on benefits from this method is published and publicized.

Fire Protection

(See also entries 46, 320, 328, 435)

502. ATMA RAM. Brushwood burning the Changa Manga plantation. illus. Indian Forester 32(2): 64-67. Feb. 1906.
Article discusses 6 points in favor of light burning, and 15 against the practice.

503. AYRES, R. W., and Hutchinson, W. I. Light burning. Jour. Forestry 30(8): 1017-1018. Dec. 1932.
The authors hold that light burning is both impracticable and expensive for large areas. In actual practice, if litter is damp it will run slowly, if at all. To "clean burn", the litter must be so dry that it will destroy small trees and reproduction and thus endanger future forest growth. Light burning causes "cat faces" to merchantable timber. It will not keep down pine-beetle infestations; the year following, on burned-over areas insect attacks increase 250 per cent. Periodic burning at first increases forage plant growth, but later noxious weeds, which are more hardy than forage plants, take possession. Light burning injures productivity of the soil. The humus is destroyed, soil is exposed, erosion follows, and the mineral salts necessary for plant growth are washed away.

504. BAKHSH, K. S. A. Control measures for the protection of the regeneration of Pinus longifolia. illus. Indian Forester 58(7): 369-387. July 1932.
Use of fire as a silvicultural tool in management of this species is recommended. Article describes methods used, how often used, and beneficial results.

505. BICKFORD, C. A., and Bull, Henry. A destructive forest fire and some of its implications. New Orleans, La., 1935. 4p. processed. (U. S. Forest Serv. Southern Forest Expt. Sta. Occasional Paper 46)
This forest fire in second-growth longleaf pine which

had been completely protected for 16 years was so destructive that the authors are inclined to doubt the wisdom of complete protection from fire, and instead, to practice controlled burning at 3- to 5-year intervals, depending upon the fire hazard.

506. BOERKER, R. H. Light burning versus forest management in northern California. illus. Forestry Quart. 10(2): 184-194. June 1912.

The author traces the history of light burning practiced by the Indians, pioneers, stockmen and lumbermen, and shows in figures the enormous expense and waste it entails. From the silvicultural point of view he summarizes results of light burning which depend, of course, upon the intensity of the fire: (1) Removes nitrogen from soil. (2) Removes protective cover and promotes evaporation from soil. (3) Fire is followed by insects and fungi. (4) Causes pitchy butts, and hence, inferior lumber. (5) Encourages weeds and brush. (6) Promotes inferior forest types. (7) Kills valuable reproduction. (8) Destroys humus, which keeps soil loose and flocculated.

507. BRUCE, Donald. Light burning: report of the California forestry committee. Jour. Forestry 21(2): 129-133. Feb. 1923.

The California forestry committee was organized in 1920 to study the question of light burning. The article summarizes arguments for and against the practice, and describes an experiment held at Moffatt Creek, Calif., to determine results of light burning. The author enumerates 10 conclusions, most of them against the practice. In 1923 the committee voted to discontinue the experiment.

508. BURNING sentiment dangerous! Pa. Dept. Forests and Waters. Serv. Letter 9(2): 27-28. Feb. 1938.

An excerpt from Pennsylvania Game News (no date given) to prove the fallacy of the efficacy of controlled burning, with notes on experiments conducted jointly by the Pennsylvania Dept. of Forests and Waters and the Game Commission.

509. CALIFORNIA state board of forestry. Biennial report, 9th, 1923. Sacramento, Calif. State print. off., 1923. 73p. illus.

Contains (p. 35-39) the final report of the California forestry committee, formed in 1920 to investigate the "light burning" theory. Includes the historical background of this controversy, describes experiments in detail, the findings (under 10 headings), and the decision to discontinue the experiment (Jan., 1923).

510. [CALIFORNIA forestry committee.] California forestry committee discontinues light burning. Amer. Lumberman (2488): 45. Jan. 20, 1923.

Summary of the aims of the committee, the results of three years of study on light burning, and conclusions reached.

511. CANNING, F. Fire to fight fire. Jour. Forestry 25(5): 597-601. May 1927.

"Controlled burning on an experimental basis" quoted verbatim from "Report on resin industry and report on forest administration in the Kumaun circle, 1925-1926." In regeneration and resin tapping areas 41,837 acres were burned at an average cost of two annas per acre. Describes burning methods used, etc.

512. CLEGHORN, H. F. C. Report upon the forests of the Punjab and the western Himalaya. Roorkee, Thomason, civil engineering college, 1864. [277]p. Map in pocket.

Includes an excerpt from the writing of Dr. Falconer, Supt. of the botanical gardens, Calcutta, dated 1853, on annual grass fires (p. 23-24) and Mr. Cleghorn's recommendation prohibiting grass burning in all forests except chil. (p. 191)

513. CUFF, Ivan. Using fire in our work. Service Bul. (U. S. Forest Serv.) Jan. 24, 1921, p. 6-7.

Use of fire in burning stumps and snags which are fire hazards.

514. DAVIS, K. P., and others. Stand improvement measures for the western white pine type. [Missoula, Mont.] 1936. 63p. mimeo. "Literature cited": p. 62-63. (U. S. Forest Serv. Region 1 and Northern Rocky Mountain Forest and Range Expt. Sta.)

Includes a chapter on clear-cutting and broadcast burning, and effects. Such methods help to perpetuate the valuable white pine species and to control fire hazard.

515. DAWKINS, C. G. E. Fire protection in plantations. Indian Forester 52(11): 561-565. Nov. 1926.

"Fires cause more severe damage under protection than with periodic burning." - E. N. Munns, in Biol. Abs. 2(1/2): 253. Jan./Feb. 1928.

516. FAIRBANKS, H. W. Shall we use fires as an aid to forestry? illus. Overland Mo. 57(3): 304-312. March 1911.

A discussion of "light burning" and "uncontrolled fire" under these headings: (1) Effects upon the forest itself (age, type, etc.) (2) Effects on humus and soil. (3) Effect on run-off. This is a reply to an article

by G. L. Hoxie, which appeared in the Sunset Magazine, 25(2): 145-151, Aug. 1910. (See entry 533)

517. FIRE control in forests; The ghost of light burning. Australian Forestry Jour. 7(10): 267-268. Oct. 15, 1924.
A short non-technical article on the failure of light burning to solve the forest protection problem, citing the results of the California forestry committee's findings.

518. FRYER, C. P. Light burning in California. Sci. Amer. 123(22): 543. Nov. 27, 1920.
The author advocates light burning, citing figures for fire losses in California in 1912 and later, which are increasingly heavier year by year, as a result of letting brush accumulate. He notes the splendid timber in the region which has survived light burning for several centuries.

519. GLOVER, H. M. Departmental firing in chir (Pinus longifolia) forests in the Punjab, Rawalpindi division. illus. Indian Forester 40(6): 292-306. June 1914.
Description of experiments showing that in all except regeneration areas woods can be fired on a large scale without doing appreciable damage to chir forests. Includes a discussion of the effects of large slow-burning fires on the tree crop, on the undergrowth and on the soil covering. Appendixes show in tabulated form results in 13 fired areas.

520. GLOVER, H. M. Fires and fire protection in chir (Pinus longifolia) forests. illus. Indian Forester 53(6): 328-338. June 1927.
The author notes difference of degree of fire resistance of chir seedlings of different soils. Résumé of fire history in Rawalpindi and effect of fire upon regeneration and resin tapping stands. Outlines experiments with fire, and offers suggestions for correct management of regeneration areas.

521. GORRIE, R. M. Protective burning in Himalayan pine. Jour. Forestry 33(8): 807-811. Sept. 1935.
Recognizing the similarity of longleaf and western yellow pine types to the Himalayan chir pine (Pinus longifolia) the author describes burning methods in that region, which were introduced because foresters have admitted that fire is inevitable, and so are using it as servant instead of master. Burning every second or third year, according to the intensity of protection needed, is now a routine measure in most of the chir stands in Punjab and the United Provinces.

522. GRAVES, H. S. The Forest service and light-burning experiments. Amer. Lumberman (2337): 76-77. Feb. 28, 1920.
The Chief Forester explains the Forest Service objection to using large areas of national forest land upon which to experiment with light burning.

523. GRAVES, H. S. Graves terms light burning "Piute forestry." Timberman 21(3): 35. Jan. 1920.
The Chief Forester, U. S. Forest Service, takes issue with the theory that light burning can take the place of an adequate fire protection program. In every case of light burning, at least a large part of the young growth is killed and more or less injury has been done to old timber except in cases where it has been protected by methods which must be so costly as to be prohibitive.

524. GRAVES, H. S. Protection of forests from fire. In his Principles of handling woodlands. N. Y., John Wiley and sons, 1911. p. 225-309.
Controlled burning as a protective measure is justified only under special conditions and only on selected areas. Six considerations on its use and abuse, p. 265-267.
A discussion of damage by grass, brush, ground and crown fires under these headings: Death to standing trees; injury to trees; injury to the soil; reduction of the density; influence on reproduction.

525. GRAVES, H. S. The torch in the timber, by H. T. (!) Graves. Sunset Mag. 44(4): 37-40, 80-90. April 1920.
A reply to article by Steward Edward White, which appeared in the previous number of Sunset Magazine (See entry 576) recommending light burning. Mr. Graves, Chief Forester, discusses light burning and uncontrolled fire and the harmful effects of both, under 6 major headings. See also entry 574 for Mr. White's rebuttal to this article.

526. GRAVES, H. S. United States forester's attitude on "light burning." Pioneer West. Lumb. 6 (8): 23-24. April 15, 1914.

527. GREELEY, W. B. "Piute forestry", or the fallacy of light burning. Timberman 21(5): 38-39. March 1920.
This article opposes light burning. Author says "light burning is simply part of the game of timber mining."

528. HADLEY, E. W. Controlled burning--if any. In Georgia. University. Forestry Club. The Cypress Knee, 1935, p. 38-39.
It is pointed out that because controlled burning is a useful silvicultural tool under certain conditions in restricted localities within the southern pine region, it is being heralded in many quarters as a panacea for the entire forest fire problem--that is, it is better to lose some timber every few years by light burning

than to lose a larger amount in the long run by uncontrollable inevitable ones. The author holds that adequate fire suppression is cheaper and more efficient than so-called controlled burning.

529. HARDTNER, H. E. Reforestation--controlled burnings. illus. Lumber World Rev. 36(12): 68-69. Dec. 25, 1918. Appears also in (not illus.) Lumber Trade Jour. 74(10): 35-36. Nov. 15, 1918.

Controlled burning in forests of the Urania Lumber Co. in Louisiana, as protection from uncontrolled fires. Methods used.

530. HARDTNER, H. E. A tale of a root--a root of a tale or, root, hog or die. Jour. Forestry 33(3): 351-357. March 1935.

Experiments on the Urania Lumber company forest in Louisiana carried on since 1915 have convinced the owners that controlled burning methods in longleaf pine should be followed every five years or oftener, and trees should be thinned, leaving a stand of 300 to 400 trees to an acre. Comments on controlled burning by several foresters follow the paper.

531. HODGSON, E. M. A new method of fire-protection. Indian Forester 32(3): 145-146. March 1906.

A discussion of a system of light, early burning as a means of fire protection in parts of India.

532. HOWELL, P. N. My experience with fire in longleaf pine. illus. Amer. Forests 38(3): 155-157, 184. March 1932.

A non-forester opposes light burning in the longleaf pine type in the South because slash pine, in areas where it will grow, is a better timber crop, and this species cannot stand fire and survive. Light burning promotes spread of scrub oak, and if severe enough to kill scrub oak, must certainly also injure longleaf pine seedlings, fire resistant as this species is. The author's experience is, that controlled annual burning costs three times as much as complete protection.

533. HOXIE, G. L. How fire helps forestry; the practical vs. the federal government's theoretical ideas. illus. Sunset Mag. 25(2): 145-151. Aug. 1910.

A practical lumberman, in collaboration with S. O. Johnson and G. X. Wendling, protests the Forest Service's fire protection policy in California, and advocates light burning. A reply to this article, by H. W. Fairbanks, appears in Overland Monthly for March, 1911, which see. (Entry 516)

534. KAY, James. Has fire any place in the forest? illus. Canad. Forest and Outdoors 26(7): 400-402. July 1930.

A forest engineer from British Columbia believes that judicious burning of the soil encourages Douglas fir to take root and grow, and also keeps harmful forest insects at a minimum.

535. KESSELL, S. L. The damage caused by creeping fires in the forest. Perth, Govt. printer, 1924. 15p. (Western Australia. Forests Dept. Bul. 33)

This is a reprint of entry 539 with a foreword by the Conservator of Forests in Western Australia. Résumé appears in Australian Forestry Jour. 7(4): 96-98. April 15, 1924.

536. KITTS, J. A. California divided on light burning. Timberman 21(3): 36, 81-82, 84, 86. Jan. 1920.

A civil engineer reaches these conclusions: Forest litter is the cause of destructive forest fires. Live trees do not burn without inflammable fuel (litter) to sustain them. Burning the litter, as is done in back-firing, is practicable and successful in coniferous forests. The prevalent American forest policy, based upon old-world conditions where the litter is gathered for fuel is a misconceived one, and should be revised. This article is an abstract from a pamphlet by the Southern Pacific Company. Comments upon it, by Paul G. Redington, District Forester, San Francisco, follow the article.

537. [KITTS, J. A.] Piute forestry; the story of the white man's error, [by "Jac Bigpipe."] Amer. Lumberman (2310): 43-44. Aug. 23, 1919.

The author, as the mouthpiece of the Indian, prepares this brief for light burning. (1) It prevents destructive forest fires and makes timber growing a conservation business. (2) It makes grass and small trees grow, instead of being smothered. (3) It thins and destroys defective trees and is a natural silvicultural agent. (4) It suppresses tree-killing insects and removes old dead growth. (5) It suppresses brush, and allows trees to extend growth into the chaparral areas. (6) It makes lumbering and roadbuilding more economical and safe.

538. KOTOK, E. I. Fire, a problem in American forestry. Sci. Mo. 31: 450-452. Nov. 1930.

A discussion of destructive effects of fires upon virgin and cut-over forests. Lists degrees of fire damage susceptibility of several tree species, and emphasizes the danger of light burning in western forests.

539. LIGHT burning as a method of forest protection; report of forestry officials after extended study. Timberman 24(9): 134-136, 138, 140-141. July 1923.

A compressed historical summary of findings, reports and experiments for and against light burning in California and the West.

540. LIGHT burning is a mistake [an editorial]. Amer. Forests 26(314): 68-69. Feb. 1920.

Reasons why the American Forestry Assoc. and the U. S. Forest Service oppose light burning.

541. LIGHT burning on pine forests. Amer. Forestry 19(10): 692. Oct. 1913.

Note on studies conducted by the U. S. Forest Service on the Wallowa and Whitman national forests in Oregon, and summary of findings.

542. LIGHT burning theory impracticable. Timberman 24(7): 106-108. May 1923.

A history of the three-year light burning experiment carried on in Moffett Creek, Siskiyon County, California, at the suggestion of the California Forestry Committee, the California State Forester, with U. S. Forest Service men making the technical observations. Ten conclusions were reached which confirmed the Forest Service's complete fire exclusion policy which it had announced in 1919.

543. MacDANIELS, E. H. National forest jungles; the theory of "light burning" in yellow pine is disproved. illus. Timberman 25(3): 50-51. Jan. 1924.

A Forest Supervisor's objection to brush burning in the West.

544. MACKENZIE, Thomas. Light burning on British Columbia forest lands. illus. Natl. Wool Grower 14(11): 23-24. Nov. 1924.

The Commissioner of Grazing, Victoria, B. C., mentions an experiment to be conducted by the Dominion government and summarizes findings to date which indicate that where fire has been prevalent both grazing and water supply are inferior. A large percentage of growth following a fire is pulled up by the roots in grazing. The gist of a resolution passed by the Upper North Thompson Stock Assoc.: "That burning the range at any time of the year destroys fertility and humus, and is detrimental to the growth of every kind of forage."

545. MANSON, Marsden. Preserving the forests by fire. illus. Water and Forest 2(3): 5-6. Oct. 1902.

Excerpts from an article on light burning by H. J. Ostrander, and from an editorial, both from the San Francisco "Call" of Sept. 23d, 1902, and both commending the practice are quoted as an introduction to this article. The author then points out the fallacy of the practice and explains that the major functions of forestry--to safeguard the future timber supply, and to conserve moisture--are hindered by practicing light burning.

546. MILLER, Joaquin. [Paper read before the 6th annual meeting of the American Forestry Congress in Springfield, Ill., Sept. 16, 1887]. Proc. Amer. Forestry Cong. 6: 25-26. 1887.

A poet and essayist, who spent his boyhood with Indians, commends the practice of light burning in the spring, after the leaves have served their time of holding back floods and nourishing the earth. He concludes that if all forest land were ceded to the States and smaller political divisions and light burning practiced upon it, there would be no more floods or fire or drought or drowning rains in California, Louisiana, Michigan or New York.

547. MUNGER, T. T., and Westveld, R. H. Slash disposal in the western yellow pine forests of Oregon and Washington. Wash., Govt. print. off., 1931. 58p. illus. "Literature cited": p. 57. (U. S. Dept. Agr. Tech. Bul. 259)

Includes technic, advantages and disadvantages of seven methods of burning slash. Several paragraphs on relation of burning to reproduction and soil values, and the effectiveness of disposal by burning in reducing Ribes population in stream bottoms.

548. OGLE, C. E. Light burning. Timberman 21(9): 106-108. July 1920.

The author champions light burning. He believes that it thins the stand and enables the remaining timber to grow better, and makes it easier to remove ripe timber. He holds that light burning destroys the pine beetle, and will prevent conflagrations in the forest.

549. OKLAHOMA. Forest service. Fires, forest and grass: everyman's enemy... in cooperation with the U. S. Forest service. Oklahoma City, 1928. 8p. illus. (Okla. Forest Serv. Pub. 4)

Light burning of the range and the effect of fires on game, tree reproduction and growth.

550. OLMSTED, F. E. Fire and the forest; the theory of light burning. illus. Sierra Club Bul. 8: 43-47. Jan. 1911.

At the time this article was written, the author was District Forester for California. He explains the prohibitive cost of effectively light burning all the national forests of California as a fire protective measure, and opposes light burning as ordinarily practiced on private lands because of (1) the destruction of most of the growth up to 20 years of age. (2) It does not kill brush. (3) It does not prevent crown fires.

551. OLMSTED, F. E. Light burning in California, by... U. S. Forest Service [Wash., Govt. print. off.,] 1911. 4p.

An exposition of Forest Service policy of light burning which is, briefly: (1) It is safe if the ground is prepared carefully beforehand, if carried out under stringent restrictions. The expense involved makes it impracticable and prohibitive in areas larger than lumbering slashes. (2) General use of light burning, even if it protected the present mature timber, would prevent new growth.

552. OPPOSING views regarding light burning or "Piute forestry" for fire protection set forth. Amer. Lumberman (2333): 61. Jan. 31, 1920.

Quotes correspondence exchanged between B. A. McAllaster, of the Southern Pacific Co. and P. G. Redington, of the Forest Service on light burning.

553. OSTROM, C. E. Servant fires. Amer. Forests 44(3): 118-119. March 1938.

Description of burning of strips along highways in New Jersey by state rangers and CCC workers as a fire prevention measure.

554. PETERS, J. G. Woods burning in the South. Raleigh, N. C., 1929. 7p. (N. C. Dept. Conservation and Dev. Div. Forestry. Circ. 20)

A popular leaflet addressed to the public, discouraging light burning.

555. PRATT, M. B. Results of "light burning" near Nevada City, California. Forestry Quart. 9(3): 420-422. Sept. 1911.

Describes results of light burning by ranchers on second-growth yellow pine from a sample one-fourth acre plot representing fairly the 15 acres burned over. The author shows that all the growth up to ten years of age, three-fifths of the 10-20 age group, and two-sevenths of the 20-40 age group were killed, and that the burning has not offered protection, because the brush will become denser after the fire and the dead needles resulting from the fire will add fuel for the next fire.

556. PRING, N. G. Note [on fire and fire protection in chir forests]. Indian Forester 53(6): 338-340. June 1927.
Notes following article by H. M. Glover (See entry 520) on use of fire in chir areas.

557. REDINGTON, P. G. What is the truth? The Forest service and Stewart Edward White agree to study forest fire damage. Sunset Mag. 44(6): 56-58. June 1920.
The conclusion of a series of controversial articles by S. E. White, and members of the U. S. Forest Service, on light burning.

558. ROTH, Filibert. Another word on "light burning." Amer. Forestry 26(321): 548, 572. Sept. 1920.
Comments on Stewart Edward White's brief for light burning (See entry 576). The author points out dangers of this theory and suggests further research on it.

559. ROTHKUGEL, Max. Forest management in southern pines. Forestry Quart. 5(1): 1-10. March 1907.
Includes a section on burning fire lines. Mentions three reasons why area should be burned over before lumbering and a note on burning the rough.

560. SHEBBEARE, E. O. Fire protection and fire control in India. British Empire Forestry Conf. 3: 715-720. 1928.
A summary of controlled burning versus protection controversy in India from 1883 to 1928, setting forth beneficial and harmful effects. Early burning is now the general rule and complete protection is extended only to plantations and regeneration areas. The author predicts that more and more as the use and control of fire is mastered we shall gain from its beneficial effects and suffer less from its destructive powers.

561. SHERMAN, E. A. Playing with fire. Outlook 134(7): 338-341. July 4, 1923.
A reply to an article by E. C. Crossman which appeared in Outlook (June 27, 1923) in favor of light burning.

562. SHOW, S. B. Forest fire protection in California. Timberman 21(3): 37, 88-90. Jan. 1920.
A résumé of three plans of light burning and an examination of fifteen claims made by their advocates, most of them dealing with fire protection. The author's conclusion is that light burning is an ideal protective measure in theory, but in actual practice it does not protect; that it is too costly to be practicable.

563. SHOW, S. B. Light burning at Castle Rock. tables. Proc. Soc. Amer. Foresters 10(4): 426-433. Oct. 1915.
Experiments by Forest Service to secure data on the effects of light burning upon reproduction of a grazed California forest, yellow pine predominating, and the efficacy of light burning in fire control. Fire was so light as to keep damage to a minimum. However, practically all reproduction up to fifteen years old was annihilated; 60 per cent of reproduction from 15 to 25 years old was killed. The author concludes that light burning reduced the fire danger for part of one fire season, but the increase of the danger after that period more than off-set the temporary advantage.

564. SHOW, S. B. The "light burning" fallacy. Service Bul. (U. S. Forest Serv.) 8(33): 2-3. Aug. 18, 1924.
A summary of Forest Service policy with reference to light burning in California.

565. SHOW, S. B. The "light burning" menace to California forests. West Coast Lumb. 55(651): 50. Nov. 15, 1928.
The District Forester in California, an anti-light burner, presents the arguments put forth by adherents of the light burning theory, and points out the danger and impracticability of each of them.

566. SHOW, S. B., and Hammatt, R. F. Will fire prevent fire? - a discussion of "light burning." Pioneer West. Lumberman 73(3): 8-9, 11. Feb. 1, 1920.
Two Forest Service men answer the advocates of light burning in the western pine forests with these conclusions: (1) Light burning, although it theoretically appears to be an ideal protective measure, in actual practice does not protect. (2) It does serious measurable damage to reproduction, which is essential to perpetuation of our forests. (3) Damage to merchantable timber from light burning is greater than the cost of fire prevention. (4) Fire protection by exclusion as practiced by the Forest Service has been successfully demonstrated for ten years, whereas the light burning method is still in theoretical stage.

567. SIMERLY, N. G. T. Controlled burning in longleaf pine second-growth timber. Jour. Forestry 34(7): 671-673. July 1936.
Narrative by a practical woodsman who is practicing controlled burning successfully on 40,000 acres of land in Baldwin county, Alabama. Mortality in a slash pine stand about two feet high was less than ten per cent. The author intends to try this method for five more years before he is convinced of the wisdom of annual controlled

burning in this region. Introductory note by Prof. H. H. Chapman.

568. STUB-BURNING experiment. Jour. Forestry 16(4): 479-480. April 1918.

Experiments at Cornell on burning old stubs with gasoline to lessen fire and insect menace.

569. TREVOR, C. G. Fire protection. Lahore, 1932. 11p. (Punjab Forest Leaflet 8)

"The general policy and methods of fire protection in the Punjab are described. Fire lines, and controlled burning in regeneration and resin tapped areas are dealt with." - H. G. Champion, in Biol. Abs. 7(7): 1696. Aug./Sept. 1933.

570. TURNER, J. E. C. Slash in relation to controlled burning. In his Slash in chir pine (Pinus longifolia) forests. Calcutta, Central publication branch, 1928. 46p. illus. (Indian Forest Rec. (silvicultural ser.) v. 13, pt. 7.)

Directions given for slash burning so as not to injure reproduction, and the importance of disposing of slash before applying controlled burning in chir seedlings of two and three feet in height (which, according to experiments is a safe size) and in areas under resin tapping.

571. WEAVER, R. B. The burning of dead and down trees as a practical protection measure. Jour. Forestry 19(5): 506-511. May 1921.

Experiment in burning dead standing western yellow pine on the Modoc National Forest, California, at a total cost of 6 cents per tree, and 14 cents per acre. Article gives six points of application of this method as a fire protection measure.

572. WESTERN AUSTRALIA. Forests dept. The foresters' manual, pts. 2-5. Perth, Govt. print., 1927. 118p. figs. (Western Australia. Forests Dept. Bul. 39)

Part 3, fire control, contains directions for controlled burning. Page 30 describes types of area afforded complete fire protection in Western Australia. "The remainder of the forest will not be afforded complete fire protection, and will be burnt under control in regular cycles. In view of the fact that bush will carry a fire only every three years, approximately one-third of the area will be dealt with each year, so that the whole area will be covered in a three-year cycle." - p. 30. There follow plans, directions, etc. for efficient and safe burning.

573. [WHITE, S. E., and others.] Arraigns the Forest service's policy on controlled burning in California. Amer. Lumberman (2332): 62. Jan. 24, 1920.

Stewart Edward White discusses the Forest Service's fire protection policy and declares it wrong. Article quotes comments by the president of the California White and Sugar Pine Association, and representatives of other lumber companies on light burning and possible cooperation with the Forest Service in experiments to test the efficacy of the practice.

574. WHITE, S. E. Getting at the truth. Is the Forest Service really trying to lay bare the facts of the light-burning theory? Sunset Mag. 44(5): 62, 80-82. May 1920.

A reply to the Chief Forester's article "The torch in the timber" (Entry 525). See also conclusion of this series of articles on light burning in California which appeared in Sunset Magazine from March to June, 1920, by P. G. Redington (Entry 557).

575. WHITE, S. E. Surface burning. Amer. Lumberman (2182): 36-37. March 10, 1917.

A discussion of light burning as a possible means of controlling the Western yellow pine beetle.

576. WHITE, S. E. Woodsmen, spare those trees! Why fire protection does not really protect our remaining timber. illus. Sunset Mag. 44(3): 23-26, 108-116. March 1920.

A brief for light burning in California forests and a suggestion that the Forest Service experiment with the practice.

Silviculture

(See also entries 44, 84, 96, 103, 132, 149, 150, 177, 225, 227, 267-269, 271, 272, 280, 292-294, 302, 353, 400, 412, 415.)

577. BENSKIN, E. Annual progress report of forest administration in the province of Bihar and Orissa for the year 1929-1930. Bihar and Orissa, Patna, Govt. printer, 1930. 72p.

"Repeated burning is being resorted to as a means of eradicating the sal thicket fungus..." - M. V. Laurie. Biol. Abs. 6(5): 1437. May 1932.

578. CHAMPION, H. G. Silvicultural research manual for use in India. vol. 1. General. (The experimental manual). Calcutta, Govt. of India, 1931. 181p.

Section 515 is on burning in connection with regeneration problems. Lists nine ways in which burning may affect regeneration.

579. CHAPMAN, H. H. Effect of fire in preparation of seedbed for longleaf pine seedlings. tables. Jour. Forestry 34(9): 852-854. Sept. 1936.

Results of experiments by Yale School of Forestry at Urania, La. Controlled winter burning during longleaf pine seedlings' first 7 and 8 years kills competing vegetation whose survival will exclude longleaf. It will control the brown spot disease for at least two years, and will prevent disastrous fires which may kill 90 per cent of seedlings before height growth starts.

580. CHAPMAN, H. H. Factors determining natural reproduction of longleaf pine on cut-over lands in La Salle parish, Louisiana. New Haven, Yale university, 1926. 44p. tables, plates. (Yale university. School of forestry. Bul. 16)

"One of the most significant findings is that very good natural establishment of longleaf pine is obtained following light spring burning of the area. The fire removes the litter and dead tangled grass which otherwise prevent germination and survival. Hardwood sites where loblolly pine thrives should not be burned because this pine is less resistant to fire than is longleaf. Fall fires kill practically every young longleaf pine under 10 feet in height, spring fires are much less destructive. Effect of hogs, grazing, grass-sods and other factors on reproduction." - From Biol. Abs. 1(6): 931. Oct. 1927. E. L. Demmon and E. W. Hadley in Jour. Forestry 24(7): 807-811, Nov. 1926, take issue with the author's results on effects of fire on survival.

581. CHAPMAN, H. H. Some further relations of fire to longleaf pine. Jour. Forestry 30(5): 602-604. May 1932.

The author distinguishes between (1) burning preceding seeding and subsequent complete or periodic protection and (2) complete protection before and after seeding. He holds that the ground must be freed of competing material prior to seed fall by means of fire but that annual burning subsequent to seeding is highly detrimental. Describes reproduction and burning experiments in Louisiana and Florida.

582. CHAPMAN, H. H. The use of fire in regeneration of certain types of forests in India. Jour. Forestry 25(1): 92-94. Jan. 1927. Abstracted by P. C. Wakeley in Biol. Abs. 2(6/8): 1174. June/Aug. 1928.

After quoting from Greswell (Entry 585), the author states that after 20 years of observation he is convinced that: (1) Longleaf seedlings will not become established in sufficient quantities upon a heavy litter of three to four years accumulation. (2) Longleaf seedlings will not

survive competition with hardwoods or loblolly unless freed from their competition by one or two fires occurring before longleaf begins height growth. (3) Fire is beneficial and perhaps necessary as protection against the defoliating fungus, Septoria pini. Author raises the question, "Are we pussyfooting in our silviculture in order to progress in fire protection education with the public?" It is pointed out that the conclusions hold for longleaf pine only, and that light burning in western yellow pine has been found to be uniformly destructive.

583. DUTHIE, E. C. Nursery weeding: a new method of weed-control in the nursery. pl. Scottish Forestry Jour. 41(1): 52-54. March 1927.
Method of burning for weed control in nurseries. The author answers criticisms of silviculturists as to injury to seeds and seedlings and gives costs and summarizes the effectiveness of burning in annual weed control.

584. FORESTS burned to increase growth of trees. illus. Pop. Mechanics 41(1): 78. Jan. 1924.
Scrub lands in the West burned to clear for planting of fir.

585. GRESWELL, E. A. The constructive properties of fire in chil (Pinus longifolia) forests. Indian Forester 52(10): 502-505. Oct. 1926.
The author proposes to winter burn the chil forests of the Siran valley of Hazara, at 3-year intervals preceding seed fall, which, he believes, is "merely re-establishing a modified form of the environment to which the forests owe their origin." See entry 520 for comments on article by H. M. Glover.

586. HEDGCOCK, G. G. Septoria acicola and the brown-spot disease of pine needles. "Literature cited": p. 998-999. Phytopathology 19(11): 993-999. Nov. 1929.
Includes a short discussion of use of fire in controlling the disease.

587. HOLE, R. S. The regeneration of sal (Shorea robusta) forests. Indian Forester 45(3): 119-132. March 1919.
Mentions (p. 120) the use of fire in removing layer of dead leaves as greatly improving germination and increasing the number of seedlings which survive.

588. ILVESSALO, L. Versuche mit ausländischen Holzarten im Staatsforst Vesijako (The softwood stands appearing as a result of burning as a silvicultural measure in the Vesijako state forest). Acta Forestalia Fennica 2:1-18. 1913.

Land is burned a year after felling, and rye is sown. After the rye is harvested, pine is sown. Result is long slender stems and good quality wood, although not as good as naturally grown pine. Spruce is sometimes planted. Mixed stands have not proved successful.

589. MATTOON, W. R. Some practical considerations on light burning in the South. Jour. Forestry 33(12): 1004-1005. Dec. 1935.

The author points out that fire, although used as a silvicultural tool in establishing longleaf seed germination in the South, must be completely excluded in the shortleaf and loblolly belts and the slash-loblolly belts. Fire, to facilitate longleaf reproduction and to control brown-spot, will occur once in a period of 40 to 60 years.

590. MISSON, R. L'incinération des souches comme moyen de destruction de l'hylobe (Stump burning as a means of insect control). Bul. Soc. Cent. Forest. Belg. 38(10): 461-466. 1931.

"Successful control of the pine weevil, an insect causing considerable damage in coniferous plantations throughout Belgium and Germany, has been obtained in the spruce stands of upper Belgium by piling and burning all stumps and major roots in the second spring following cutting operations, the material being dug up and allowed to dry out for about eight days before burning. Burning must be completed before May 15." - I. T. Haig, in Biol. Abs. 7(5): 1168. May 1933.

591. MUNNS, E. N., and Coville, Perkins. Silvicultural practice in the control of forest insects. Trans. 4th Internat'l. Congress Ent., 1928. 2: 333-341. 1929.

"Fire may prove valuable in destroying specially treated trees and slash to which insects have been attracted. Research on the application of these principles is suggested..." - P. Coville, in Biol. Abs. 4(11): 2759. Nov. 1930.

592. OSBORNE, J. G., and Harper, V. L. The effect of seedbed preparation on first-year establishment of longleaf and slash pine. tables. Jour. Forestry 35(1): 63-68. Jan. 1937.

A study conducted on the Olustee Experimental Forest in northern Florida by the Southern Forest Experiment Station on removal of rough on first-year establishment and growth, one method being by burning. It is apparent from this study that burning, either immediately or one year before seed fall, greatly enhances the longleaf pine "catch" so that if the method of burning a year in advance or immediately prior to seed fall successfully combats the bird and rodent problem, a satisfactory stand of reproduction should result." - Quoting final paragraph.

593. ROBERTS, E. G. Germination and survival of longleaf pine. Jour. Forestry 34(9): 884-885. Sept. 1936.

Experiment at the Louisiana State University School Forest on the effect of burning off rough prior to seeding for longleaf pine showed that such burning increased germination and survival.

594. RÖHRL, Waldkatastiophen (Forest catastrophies). Forstwiss. Centbl. 72(9): 293-315. May 1928.

"The most serious foes of German forests are windstorms... Fires are particularly serious in managed forests. Insect epidemics have killed much timber... The best prospects are in chemical and mechanical measures, such as burning the leaf-litter in which certain insects spend part of their life cycle, or in spraying from aircraft or otherwise." - W. N. Sparhawk, in Biol. Abs. 4(1): 195. Jan. 1930.

595. SHEBBEARE, E. O. Fire and sal regeneration. Indian Forester 56(7): 302-306. July 1930.

Includes an outline of the method of regenerating sal by the agency of fire.

596. SHIRLEY, H. L. Does light burning stimulate aspen suckers? Jour. Forestry 29(4): 524-525. April 1931; 30(4): 419-420. April 1932.

"Light burning late in the fall on 10 ft. sq. quadrats on plots in a 43 yr. old aspen stand on the Chippewa National Forest (Minnesota) stimulated the growth of aspen root suckers apparently because of the increased heat absorption of the blackened surface." - P. C. Wakeley, in Biol. Abs. 6(2): 533. Feb. 1932.

597. SIGGERS, P. V. The brown spot needle blight of longleaf pine seedlings. pt. 2. Influence of fire as a method of disease control. "References": p. 593. Jour. Forestry 30(5): 588-593. May 1932.

Investigations in four localities disclosed that a single fire reduced the brown-spot needle disease for the following season. By the end of the second season the influence of fire on the disease was negligible on two of three areas. On the third area the amount of the disease was one-half of that on an unburned area. "A fire burning through 6-year rough caused eight per cent mortality of seedlings and delayed the height growth of a sixth of the survivors by killing the terminal bud. On an adjacent unburned area the mortality from all causes was four-tenths of one per cent." - from conclusion, p. 593.

598. SIGGERS, P. V. Observations on the influence of fire on the brown-spot needle blight of longleaf pine seedlings. "References": p. 562. Jour. Forestry 32(5): 556-562. May 1934.

Brown-spot needle blight occurs in varying severity on longleaf pine seedlings, retarding their early growth rate. A single burning greatly reduced the disease for the first season and often to a lesser extent for the second. Controlled winter burning at three-season intervals after the seedlings are established and before they emerge from the grass is a useful silvicultural measure where the disease is serious.

599. SMYTHIES, E. A. The problem of sal regeneration. Indian Forester 52(8): 395-400. Aug. 1926.

"Artificial regeneration of sal (Shorea robusta) can be obtained on a large scale and at moderate cost by taungya and by no other means. Controlled burning immediately after leaf fall in a good seed year results in abundant natural regeneration provided the rain comes in time. The growth of established reproduction can be stimulated by clear felling, cutting advance growth, burning in March and subsequent fire protection. Dense sal forests are impossible without the burning." - E. N. Munns, in Biol. Abs. 1(2/3): 351. Apr. 1927.

600. SYLVÉN, Hjalmar. Snytbaggarna (Hylobius beetles). illus. Skogsvardsför. Tidskr. 25(3): 521-551. 1927.

"Hylobius abietis and H. pinastri are serious enemies of coniferous seedlings, especially planted trees... Best results were obtained by luring the insects to pieces of spruce bark scattered on burned areas where there was little shelter for the insects... Planted trees were injured less on burned than on unburned clearings..." - From Biol. Abs. 2(9/11): 1721. Sept./Nov. 1928.

601. TSCHAEN. Neue Wege zur Bekämpfung des Kiefernspanners (New ways of combating the pine caterpillar). illus. Deutsche Forstzeitg. 44(26): 660-663. 1929.

"Most of the pupae were killed by burning the forest floor. Injury to standing trees was prevented by spraying around their bases with a $CaCl_2$ solution..." - W. N. Sparhawk, in Biol. Abs. 4(10): 2390. Oct. 1930.

602. TSCHAEN. Überlandbrennbetrieb (Broadcast burning). illus. Deutsch. Forstzeitg. 44(4): 86-90. Jan. 29, 1929.

"Broadcast burning is advocated before planting trees on acid soils covered with raw humus and heather." - W. N. Sparhawk, in Biol. Abs. 3(9/11): 2009. Sept./Nov. 1929.

603. U. S. FOREST SERVICE. Southern forest experiment station. Brown-spot disease of southern pines. In its Southern forestry note 6, 1934. p. [4].

Controlled winter burning at 3-year intervals in longleaf pine until a sufficient number of seedlings start height growth is suggested as a means of control of brown-spot disease.

604. WESTVELD, R. H. Preliminary results in eradicating weeds with zinc sulphate and by burning in forest nursery seed beds. tables. Mich. Agr. Expt. Sta. Quart Bul. 15(4): 254-261. May 1933.

p. 257-259 is on the effectiveness of burning on weed eradication which is governed by (1) time when burning is done and (2) length of time the burning is applied. Work was done with spruce and sorrel, pepper grass, and ragweed. The success of the burning depends upon burning just prior to the seedlings' appearance above the ground. Burning was cheaper than use of zinc sulphate. An 8-second burning per square foot was effective, and the effect of continued burning on the soil has not yet been determined.

605. WIBECK, Edvard. Om ljungbränning för Skogskultur (Fire as a means of culture). Meddel. fr. Statens Skogsforsoksanstalt 9(1): 1-106. 1911. Reviewed in Forest Quart. 11(2): 263-264. June 1913.

Descriptions of experiments in Sweden on 26 plots on the effect of burning on the heath prior to cultivation. Pine, spruce, and birch were used, but pine only was successful. On some sites, burning increased regeneration and height growth; on others, the opposite was true. Kind of soil, time of burning, extent of burning are the factors to take into consideration.

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